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EPIDEMIOLOGY OF STRIPE RUST IN WESTERN CANADA ¹

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During the last four years the prevalence, distribution and host range of *Puccinia glumarum* (Schmidt) Erikss. and Henn. have been closely observed in Alberta, because of the possible danger of this rust to the wheat crop of Western Canada. Most of the information presented here was obtained by extensive surveys made frequently throughout each season from May to October, and from uniform stripe rust nurseries, strategically located.

HISTORICAL

Humphrey, Hungerford and Johnson (10), and Humphrey and Cromwell (11) have given an adequate historical summary of the first appearance and subsequent collections of *P. glumarum* in the United States, Mexico and South America. Figure 1 provides a general sketch of the present known distribution of this rust in the Western Hemisphere.

From references given, stripe rust was first collected by W. S. Piper in the United States in June, 1892, on *Elymus glaucus* Buckl. and *Bromus carinatus hookerianus* (Thurb.) Shear, and in 1896 it was collected by Holway on *Hordeum jubatum* L. near Mexico City, Mexico. In the United States the first collection on wheat was made by Køplin Ravn and Humphrey, May 25, 1915, in Arizona. During 1915 and subsequently, it was observed on a number of native hosts and on wheat, which are listed in Humphrey, Hungerford and Johnson's paper. According to Arthur (8) the first records of *P. glumarum* in South America were by E. W. D. Holway, on *H. chilense* R. & S., in Chile, 1919, and on *Agropyron attentuatum* R. & S., in Ecuador, 1920. Humphrey and Cromwell (11) reported it on wheat in Argentina in 1929.

According to Johnson and Newton (12) the first collection of stripe rust in Canada was on *H. jubatum* at Edmonton by Professor W. P. Fraser in 1918. It was also found by C. E. Maguire on *H. sativum* at Vermilion in 1924. On the former host subsequent collections (1) were made by Newton (9) at Stettler in 1920, and at Camrose and McLeod, and in 1924 on *Agropyron Smithii* at Red Deer and on *A. Richardsoni* at Edmonton (7). The next record was in 1926 when Sanford (2) observed a heavy infection on several varieties of wheat and on *H. jubatum* at Olds, and again (3) in 1927 on these hosts at Olds and also near the Alberta-Montana boundary. One collection was reported that year (3)

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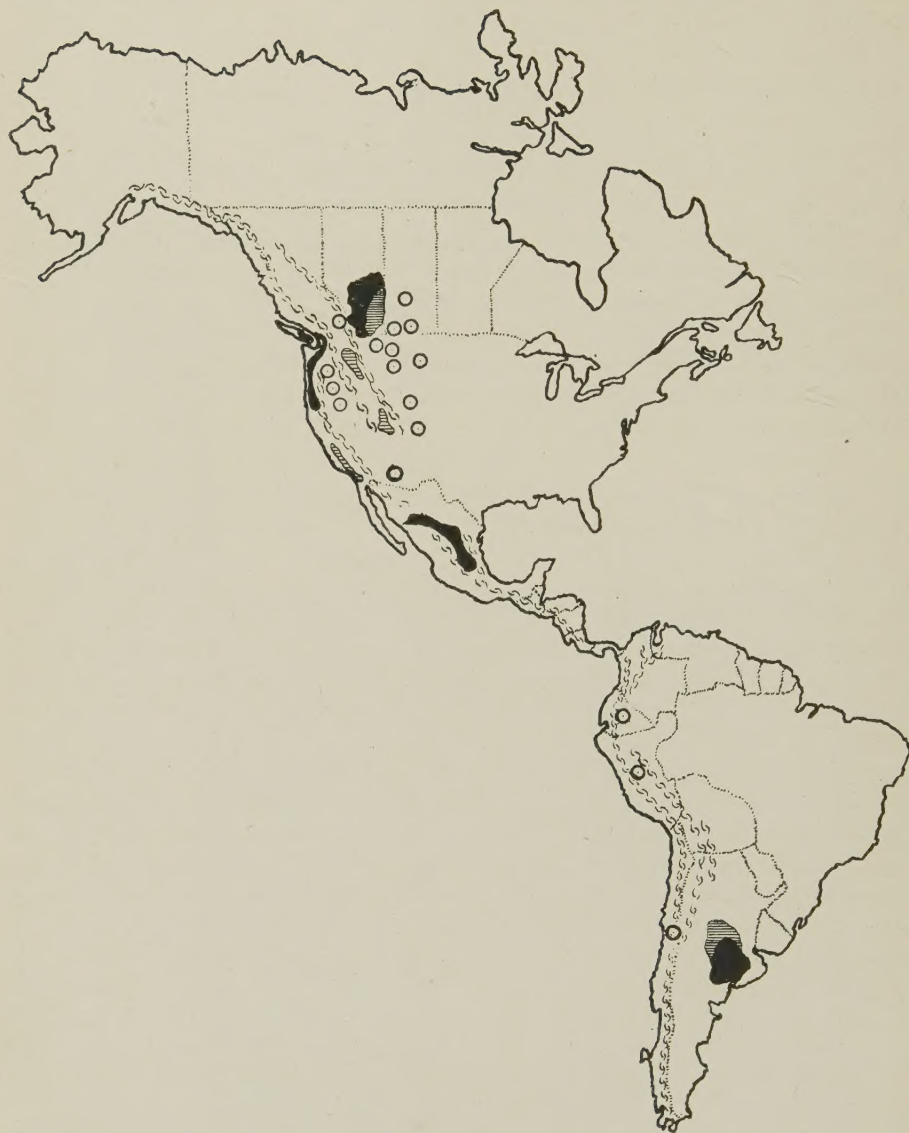


Figure 1. The known distribution of stripe rust in the Western Hemisphere. The solid and shaded areas and circles indicate the relative prevalence as abundant, light, and more or less occasional, respectively.

on *H. jubatum* at Robsart in southwestern Saskatchewan near Alberta, and is the first record for that province. In 1928, when the first extensive survey for stripe rust in Alberta was made, Sanford and Broadfoot (15) observed a very general occurrence of this rust on *H. jubatum* and also infections on wheat, *A. Smithii* and *A. dasystachyum*. In spite of the fact that stripe rust was common in Alberta on *H. jubatum*, even to the western boundary of Saskatchewan, only three cases were observed in Saskatchewan that year, one on wheat at Alsask, close to the Alberta boundary, and the others on *H. jubatum* (4) at Ponteix and Horizon, in southern Saskatchewan, some 220 miles east of Alberta. In the same report the following general statement was made concerning *P. glumarum* in British Columbia: "Stripe rust occurs commonly on the southern end of Vancouver Island, but no extensive survey has been made of that province".

In 1929 stripe rust was fairly common in Alberta (5), but it was not reported from Saskatchewan. Regarding British Columbia, the senior author made diligent search for this rust that year *en route* by car via Windermere, Cranbrook, Nelson, Grand Forks, Vernon, Kamloops, Agassiz, Vancouver and Victoria to Campbell River, on the northern part of Vancouver Island, without success. It may be mentioned that dry conditions prevailed, although hosts in many apparently favourable habitats were inspected.

In 1930 stripe rust was not reported from Saskatchewan, although it was fairly common in Alberta (6). The senior author observed a light local infection on *H. jubatum* and on *A. Smithii*, which were growing side by side near Windermere in southeastern British Columbia. This is the first collection made to date in southern British Columbia east of Agassiz, which latter point is near the coast.

In 1931 it was again fairly common in Alberta, as shown by Figure 3. According to Plant Disease Survey Report (7) Newton made a collection of *P. glumarum* on *Aegilops* sp. at Saskatoon, Saskatchewan, and also other collections on the following hosts in British Columbia, all in the area which is designated later in this paper as Zone I (coastal area) of that province: *A. Richardsoni* (Trin.) Schrad.; *Bromus marginatus* Nees; *B. sitchensis* Bong.; *Elymus glaucus* Buckley; *E. Howellii* Scribn. and Merrill; *E. marginalis* Rydb.; *Hordeum caespitosum* Scribn.; *H. jubatum*, and wheat (Dawson's Golden Chaff).

CLIMATE, TOPOGRAPHY AND HOSTS OF THE GENERAL AREA IN WHICH STRIPE RUST OCCURS

Only a brief, and at best sketchy, account can be attempted here of the general area in British Columbia, Alberta and Saskatchewan in which stripe rust has been observed. The influence of natural barriers such as mountains, forests, areas of limited rainfall, high temperatures, abundance or relative scarcity of susceptible hosts or prevailing winds, and on the distribution and supply of inoculum for the incidence of this rust should be mentioned. For this purpose British Columbia and Alberta have each been divided into three zones and Saskatchewan into two zones, viz. a central one and a southern one.

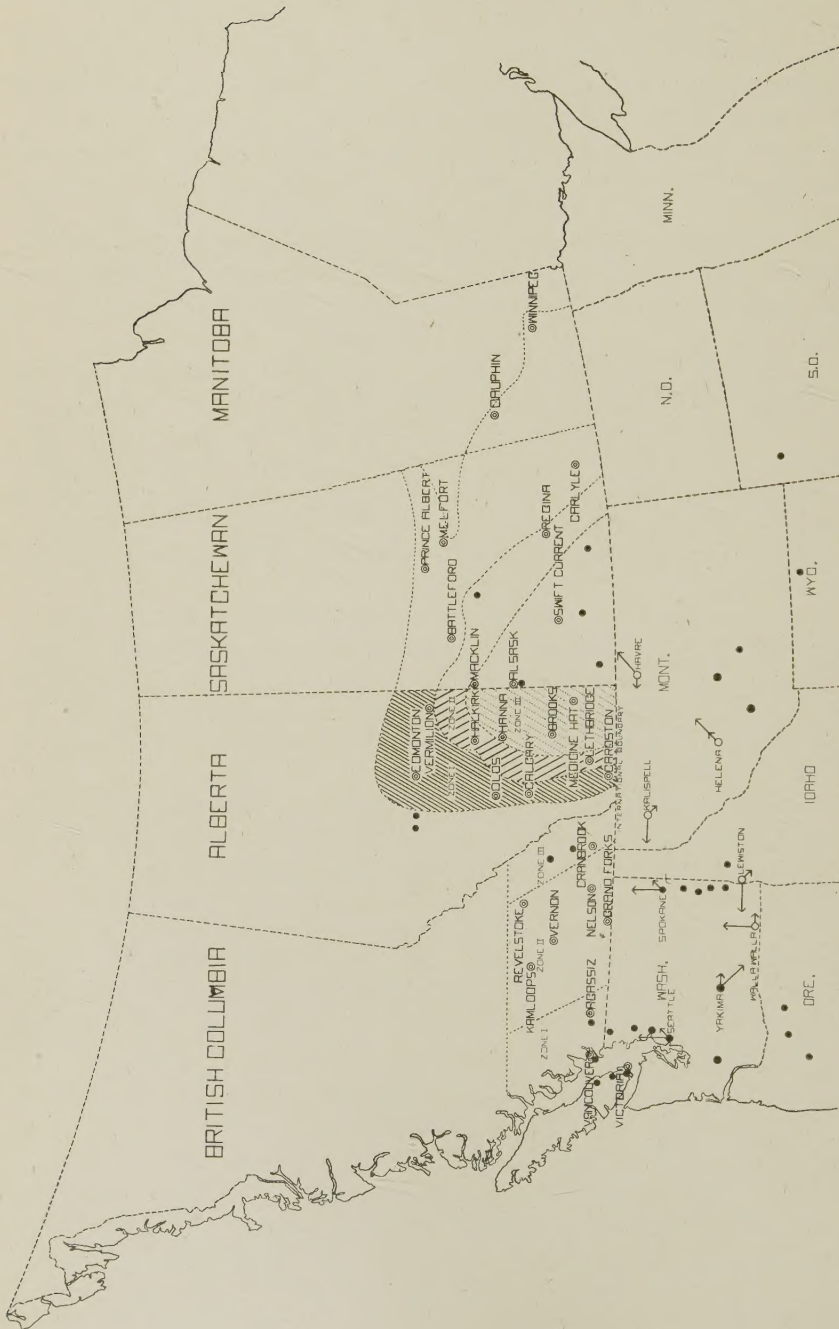


Figure 2. The distribution of stripe rust in Western Canada with particular reference to its relative prevalence in Zones I, II and III Alberta, as shown by degree of shading. The direction of prevailing winds of first and second importance at points in adjacent states is indicated by relative length of arrows.

The mean minimum and mean maximum temperatures for the late spring and summer months are reviewed because stripe rust is thought to be favoured by a low temperature and hindered by high ones. An average of each of the extremes would seem to indicate better whether temperature conditions were favourable or not, than would simple mean temperatures. Accordingly, means of the maximum and of the minimum temperatures for a given month during 1928 to 1931, inclusive, when stripe rust was more or less prevalent in Alberta, are given in degrees Fahrenheit.

Temperature data for certain representative stations in British Columbia and Saskatchewan are found in Table 1, and for Alberta in Table 2. Data for the year 1928, when stripe rust was very general in Alberta, and was also found* in Saskatchewan, are included in these tables for comparison.

BRITISH COLUMBIA

The southern portion of the province of British Columbia, roughly 150 miles north and south, and 350 miles east and west, has been divided into three zones, which are described below.

The area in Zone I comprises a coastal portion of the mainland, and practically all of Vancouver Island, on the southern end of which stripe rust occurs. In this area the rainfall is usually ample during April, May, June and September, but meagre during July and August, as indicated in Table 1. A number of susceptible hosts occur here. The data for Victoria show uniformly low precipitation, but this point is only representative of a local area contiguous to that station.

The mean minimum temperatures during June and September are roughly similar (about 50°) at Victoria, Vancouver and Agassiz, although the average is slightly lower during September on the mainland than at Victoria. During July and August, the mean minimum was about 2.3° higher than for June at Vancouver and Victoria, but at Agassiz it was about 2° higher during July, and approximately the same as for June during August. The mean maximum temperature at Victoria was roughly 64° for June and September and 69.8° and 67.6° for July and August, respectively. The mean maximum temperature at Agassiz for June and September was 68.7° and 70° , respectively.

Zone II, which lies between the coastal zone and Zone III, is bordered on the south by the States of Washington and Idaho, and on the east by the Selkirk range of mountains. This mountainous area is roughly 200 miles wide and consists of valleys and forests and, in general has distinctly less rainfall than Zone I. *H. jubatum* is extremely scarce and found only in favoured places, which are widely separated. The native *Agropyron* sp., while occurring here and there, are usually found in habitats too dry to favour rust development. Indeed, the entire area would seem unfavourable for stripe rust, and it is not surprising that it has not yet been found here.

The temperature data for Zone II are given for Kamloops in the north, Vernon in the north-central part, and Grand Forks in the south, close to the International border. The mean minimum temperature for the four years during May was 40.9° at Grand Forks, 43.6° at Vernon

and 47.1° at Kamloops. For June it was 47.5° at Grand Forks, 49.9° at Vernon and 54.5° at Kamloops. For July it varied from 50.5° at Grand Forks to 57.4° at Kamloops. The figures for August were slightly lower than those for July, while for September the mean minimum dropped to 41.5° at Grand Forks, 45° at Vernon and 47.7° at Kamloops, which are somewhat below the figures for June at these stations.

The mean maximum temperature for May was 69.2° at Vernon, $.6^{\circ}$ higher at Kamloops, and 3.8° higher at Grand Forks. During June it was 74.7° at Grand Forks and about 1° less than this at Kamloops. During September, it was practically the same as during June at Grand Forks, but about 4.6° lower at Kamloops and Vernon. The mean maximum for July and August at these two points ranged between 81.9° and 87.6° , which temperatures are unsuitable for rust development.

The data suggest that the mean minimum temperatures for the central zone during June were very similar to those of the coastal area, while the mean maximum temperatures were somewhat higher in the central area than in the coastal zone for June and September. From the standpoint of temperature alone, stripe rust should develop in Zone II during early June and September, for the temperature range then is similar to that in southern Alberta during September when the rust makes good progress.

Zone III, which comprises a narrow area about 75 miles wide, is situated in the southeastern corner of British Columbia, between the crests of the Selkirk and Rocky ranges, and directly north of where stripe rust occurs in Idaho and in the north-western corner of Montana. In this Zone *H. jubatum* is rare, and the precipitation during the summer months is limited. As in Zone II, the general area of Zone III is unfavourable for stripe rust.

The mean minimum temperatures at Cranbrook, in the southeast corner of British Columbia, during May, June, July, August and September for these four years were 36.8° , 43.3° , 45.3° , 43.0° , and 37.0° , respectively, while the mean maximum temperatures for the same period were 67.5° , 70.3° , 81.3° , 80.6° and 66.9° , respectively. The temperatures in Zone III were, on the whole, distinctly lower than the corresponding temperatures in Zone II, while compared to the coastal zone, Cranbrook registered lower mean minimum temperatures and higher mean maximum temperatures, with the exception of Agassiz in September.

If the lower mean temperature in Zone II should be favourable for the development of the rust, this advantage might be offset by the higher maximum temperatures, compared with those of the coast. It will be seen, however, that stripe rust occurs in Alberta under a range of temperatures where the mean minimum is slightly higher and the mean maximum is, in general, only slightly less.

ALBERTA

The southern half of the province (roughly 350 by 200 miles) has been divided into three zones according to the known prevalence of stripe rust to date. The foothill and wooded areas adjacent to the Rocky Mountains are not included.

TABLE 1.—Temperature and rainfall data at certain points in British Columbia and Saskatchewan.

Station	Average Temperature, degrees Fahrenheit										Rainfall, inches						
	Year	June		July		Aug.		Sept.		Year	Apr.	May	June	July	Aug.	Sept.	Six mos.
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.								
BRITISH COLUMBIA																	
Victoria	1928	50.3	63.0	53.2	68.9	51.9	65.9	49.8	63.4	1928	1.36	.32	.51	.25	.23	.45	3.12
	*4-yrs.	49.9	63.5	51.3	69.8	52.4	67.6	50.6	64.5	1929	1.13	.95	.99	.25	.26	.10	3.68
Vancouver	1928	52.3	69.1	56.0	75.9	53.2	74.6	48.8	68.2	1928	4.29	2.22	1.93	.47	.20	1.35	10.46
	4-yrs.	51.6	68.6	53.9	75.8	53.5	75.6	49.9	67.6	1929	4.81	1.25	3.24	1.41	1.50	1.77	13.98
Agassiz	1928	51.6	68.4	56.1	76.7	52.2	76.3	46.8	70.1	1928	2.81	2.03	1.98	1.41	.86	2.63	11.72
	4-yrs.	51.3	68.7	53.4	77.4	50.9	72.6	49.2	70.0	1929	2.12	4.29	3.03	.51	.95	1.47	12.37
Kamloops	1928	55.1	75.7	59.7	84.4	54.4	80.2	47.2	71.5	1928	.23	.29	1.55	1.14	.50	.37	4.08
	4-yrs.	54.5	73.6	57.4	83.1	55.8	82.1	47.7	69.0	1929	.76	.70	1.06	.63	.37	.74	4.26
Vernon	1928	51.7	73.4	55.9	82.1	52.5	79.7	45.0	69.1	1928	1.67	1.13	3.07	1.10	.29	.26	7.52
	4-yrs.	49.9	73.4	53.3	83.3	52.8	81.9	45.0	69.1	1929	.95	.41	2.63	.18	1.50	1.02	6.09
Grand Forks	1928	48.2	74.9	52.6	86.8	48.2	84.7	38.5	77.9	1928	1.36	1.27	2.74	1.00	.39	.03	6.79
	4-yrs.	47.5	74.7	50.5	87.4	49.2	87.6	41.5	74.9	1929	1.25	.22	4.61	.03	.22	.32	6.65
Cranbrook	1928	43.6	70.1	48.8	79.6	41.3	75.4	34.9	72.1	192850	1.80	2.00	1.25	.25	5.80†
	4-yrs.	43.3	70.3	45.3	81.3	43.0	80.6	37.0	66.9	1929	.32	1.34	2.19	.00	.42	1.09	5.36
SASKATCHEWAN																	
Battleford	1928	46.0	69.0	54.0	77.0	45.0	74.0	36.0	68.0	1928	.66	.53	4.09	2.39	1.08	.47	9.22
	4-yrs.	47.8	71.8	52.5	78.5	48.9	77.7	39.2	64.6	1929	.42	.95	3.75	.85	.30	1.07	7.34
Prince Albert	1928	47.0	69.0	54.0	77.0	46.0	70.0	36.0	64.0	1928	.45	.92	1.65	1.50	1.14	.20	5.86
	4-yrs.	48.6	71.2	53.6	77.0	50.0	74.8	39.9	61.3	1929	2.63	1.10	2.46	1.41	1.54	1.83	10.97
Melfort	1928	45.4	68.9	51.2	76.2	44.7	68.6	1928	.35	.61	1.23	1.49	2.55	...	6.23
	4-yrs.	47.2	71.1	51.4	76.1	48.3	74.0	40.0	55.4	1929	1.94	.96	3.66	1.96	1.25	1.73	11.73
Swift Current	1928	46.0	70.0	53.0	78.0	47.0	79.0	37.0	72.0	1928	.62	.44	4.80	2.78	.40	.14	9.18
	4-yrs.	47.6	75.0	52.4	82.5	49.9	82.3	39.0	68.7	1929	.62	2.23	3.07	1.42	.48	1.37	9.19
Regina	1928	48.2	68.9	52.0	76.0	44.3	76.5	34.1	69.2	1928	1.06	1.07	5.56	1.95	.23	.32	10.19
	4-yrs.	47.4	74.9	52.2	81.9	49.3	80.7	39.2	66.8	1929	.69	1.42	1.93	.27	.21	1.23	5.75
Carlyle	1928	43.8	67.5	50.5	72.4	43.4	74.9	32.5	64.5	1928	1.70	.28	5.12	3.04	.35	.97	11.46
	4-yrs.	44.0	72.8	50.7	79.4	46.6	78.7	34.8	65.2	1929	1.33	4.19	1.28	.68	.54	1.03	9.05

* Average, 1928 to 1931, inclusive.

† Rainfall for five months only.

TABLE 2.—*Temperature and rainfall data at certain points in Alberta.*

Station	Year	Average Temperature, degrees Fahrenheit				Rainfall, inches					
		June		July		Aug.		Sept.		Year	Sx m.s.
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
Cardston	1928	43.9	63.9	50.2	75.8	43.7	72.5	38.2	67.5	1928	
	*4-yrs.	44.8	68.7	48.4	78.7	47.6	77.9	39.1	63.2	1929	14.59† 8.83†
Claresholm	1928	43.2	65.7	50.1	74.9	44.4	72.6	36.4	69.3	1928	
	4-yrs.	45.1	65.2	48.8	79.8	47.3	80.5	37.9	67.9	1929	12.91 11.42
Clagary	1928	43.0	66.0	50.0	75.0	45.0	72.0	36.0	70.0	1928	
	4-yrs.	44.4	68.5	48.1	76.8	46.5	76.3	37.6	64.3	1929	13.06 8.99
Olds	1928	43.9	62.1	48.3	70.3	41.9	67.2	35.2	65.5	1928	
	4-yrs.	44.1	65.8	47.2	73.5	44.8	72.5	36.4	61.8	1929	15.84 8.00
Edmonton	1928	46.0	67.0	51.0	74.0	44.0	70.0	36.0	66.0	1928	
	4-yrs.	46.3	68.9	49.8	74.9	47.4	72.7	38.2	62.2	1929	12.58 10.08
Vermilion	1928	43.9	65.6	49.3	73.2	40.9	69.3	28.2	65.9	1928	
	4-yrs.	43.8	69.1	48.5	76.0	45.3	73.6	33.1	62.4	1929	11.66 6.91
Lethbridge	1928	44.8	66.4	52.9	73.5	45.7	72.1	36.5	69.3	1928	
	4-yrs.	45.7	69.9	50.3	77.9	48.2	78.9	39.1	65.6	1929	13.96 12.06
Halkirk	1928	45.7	67.0	52.3	74.9	46.3	68.1	38.1	63.8	1928	
	†2-yrs.	45.8	70.0	50.9	78.2	47.7	72.8	37.3	61.7	1929	15.23 4.64
Brooks	1928	46.4	68.6	54.1	78.6	47.4	75.0	36.9	71.1	1928	
	4-yrs.	47.2	72.8	52.4	81.5	50.0	80.9	39.1	66.3	1929	9.95 5.38
Hanna	1928	46.0	66.1	51.8	73.9	42.6	70.7	34.5	66.8	1928	
	4-yrs.	45.0	69.9	49.6	77.2	46.7	76.4	35.0	63.0	1929	10.25 4.80
Alsask	1928	44.7	69.4	50.8	77.7	44.7	76.1	35.2	69.5	1928	
	4-yrs.	44.9	72.6	50.7	80.6	46.6	81.0	37.1	66.0	1929	9.03 5.89
Macklin	1928	40.6	68.7	51.2	77.3	43.4	73.7	29.4	69.9	1928	
	4-yrs.	44.0	71.5	50.0	77.9	46.7	76.8	35.4	64.9	1929	6.91† 3.81

* Average for years 1928 to 1931, inclusive.

† Average for years 1928 and 1929.

†† Rainfall for five months.

Zone I comprises in a general way what is locally known as the black or dark-brown soil area. The part north of Calgary is mostly in the park belt and characterized by scattered patches of *Populus* and *Salix*, while the southern part, with a few minor exceptions, is open. The average annual precipitation is greater in this zone than in either of the other two zones, which lie to the east, although seasonal exceptions occur (Table 2). *H. jubatum* is very common throughout this zone. Species of native *Agropyron*, susceptible to stripe rust, also occur in this zone, being more or less prevalent.

The mean minimum temperatures during the four years at the stations chosen in this zone (Table 2) varied during June from 43.8° at Vermilion, in the north eastern part, to 46.3° at Edmonton, being for Cardston and Claresholm in the south, approximately 45.0°. During July it varied in the southern part from 48.1° at Calgary to 48.8° at Claresholm, and in the northern part from 47.2° at Olds to 49.8° at Edmonton. The figures were somewhat lower for August, ranging from 46.5° at Calgary to 47.6° at Cardston in the south, and in the northern part from 44.8° at Olds to 47.4° at Edmonton. For September, the mean minimum was approximately 38.0 at Claresholm, Calgary and Edmonton.

The mean maximum temperature during June was approximately 69.0° at all stations except Claresholm and Olds, where it was 65.5°. During July the mean maximum temperature was distinctly higher. In the south it varied between 76.8° at Calgary to 79.8° at Claresholm, while in the north it varied from 73.5° at Olds to 76.0° at Vermilion. For August it varied from 76.3° at Calgary to 80.5° at Claresholm in the south, and from 72.5° at Olds to 73.6° at Vermilion in the north. During September it ranged from about 62.0° at Olds to 64.0° at Calgary.

Zone II represents a transition from Zone I and Zone III in precipitation, soil, hosts and temperature. There is a distinct tendency for stripe rust to be less prevalent here.

Zone III comprises what is commonly classed as the short grass plains, a large area of which is common to southeastern Alberta and southwestern Saskatchewan. Data in Figure 3 show that the precipitation was usually lower throughout this area than in Zone I. The prevailing winds blow eastward. The predominating grasses are *Bouteloua* sp. and *Stipa* sp., and while *H. jubatum* is common in sloughs, which are less numerous than in Zone I, its general prevalence is much less than in Zone I. Other native hosts are *A. dasystachyum* and *A. Smithii*. In this zone we find vast stretches of land practically uncultivated in comparison with the relatively extensive cultivation in Zone I.

The mean minimum temperature for June (Table 2) ranged from 44.0° at Macklin to 47.2° at Brooks; for July from 50.0° at Hanna to 52.4° at Brooks; during August, from approximately 46.5° at Macklin, Alsask and Hanna to 50° at Brooks, and during September from 35.0° to 39.0°. These figures are slightly higher than those at stations in the southern part of Zone I.

The mean maximum temperatures for this zone during July varied from about 77.5° at Hanna to 80.6° at Alsask and Macklin and 81.5° at

Brooks, and during August from approximately 76.5° at Macklin and Hanna to 81.0° at Alsask and Brooks. Slightly higher temperatures prevailed at these points than during the corresponding months at Claresholm, Cardston and Lethbridge, in the southern parts of Zone I and II. During September the range was from 63.0° at Hanna to 66.3° at Brooks.

SASKATCHEWAN

Temperature data for the following stations are reviewed: Swift Current, Alsask, Regina and Carlyle in southern Saskatchewan, and Macklin, Battleford, Prince Alberta and Melfort in the central portion (Figure 2). The data for Macklin and Alsask were also used for Alberta, since these points are representative to both provinces.

For June the lowest mean minimum temperature was at Carlyle, being 44.0° . At the other points it varied between 47.2° at Melfort to 48.6° at Prince Albert, both points in central Saskatchewan. The mean minimum temperatures during July and August were similar each month, July varying only between 50.7° at Carlyle to 53.6° at Prince Albert, and for August from 48.3° to 50.0° at various stations, except Carlyle, where it was 46.6° .

The mean maximum temperatures at the stations in southern Saskatchewan were all higher than those in the central area. The range in the south for July was between 79.4° at Carlyle to 82.5° at Swift Current, and for August between 78.7° and 82.3° . The range in central Saskatchewan for July was from 76.1° at Melfort to 78.5° at Battleford, and for August from 74.8° at Prince Alberta to 77.7° at Battleford.

Several interesting comparisons can be made from the temperature data given for Alberta and Saskatchewan. First, the slight difference in mean minimum temperatures during any month at the points in Saskatchewan is probably not significant, in so far as stripe rust may be affected, and the same statement applies to Alberta. The mean minimum temperatures in Zone I of Alberta, during July and August, were consistently, but slightly, lower by about 2.0° than in Saskatchewan for the same periods. The mean maximum temperatures in southwestern Saskatchewan and Zone III of Alberta, were consistently higher than elsewhere by, roughly, 3.0° . Higher mean maximum temperatures prevailed in the southern part of each province than farther north. Also higher mean maximum temperatures prevailed in July than in August. Not the least important comparison is that the mean maximum temperatures in central Saskatchewan were very similar to those in the southern part of Zone I of Alberta, in which stripe rust develops well. This and the fact that stripe rust appears first and makes earlier general progress in southern Alberta, under slightly higher temperatures than farther north, suggest rather definitely that the peculiar distribution of this rust in Alberta, or the apparent scarcity of it in central Saskatchewan, cannot be explained on the basis of temperature alone.

PRECIPITATION

Obviously the number of inches of rainfall during a period of one or more months cannot convey a correct impression of actual conditions at any time, but is, nevertheless, one of the factors in the development of

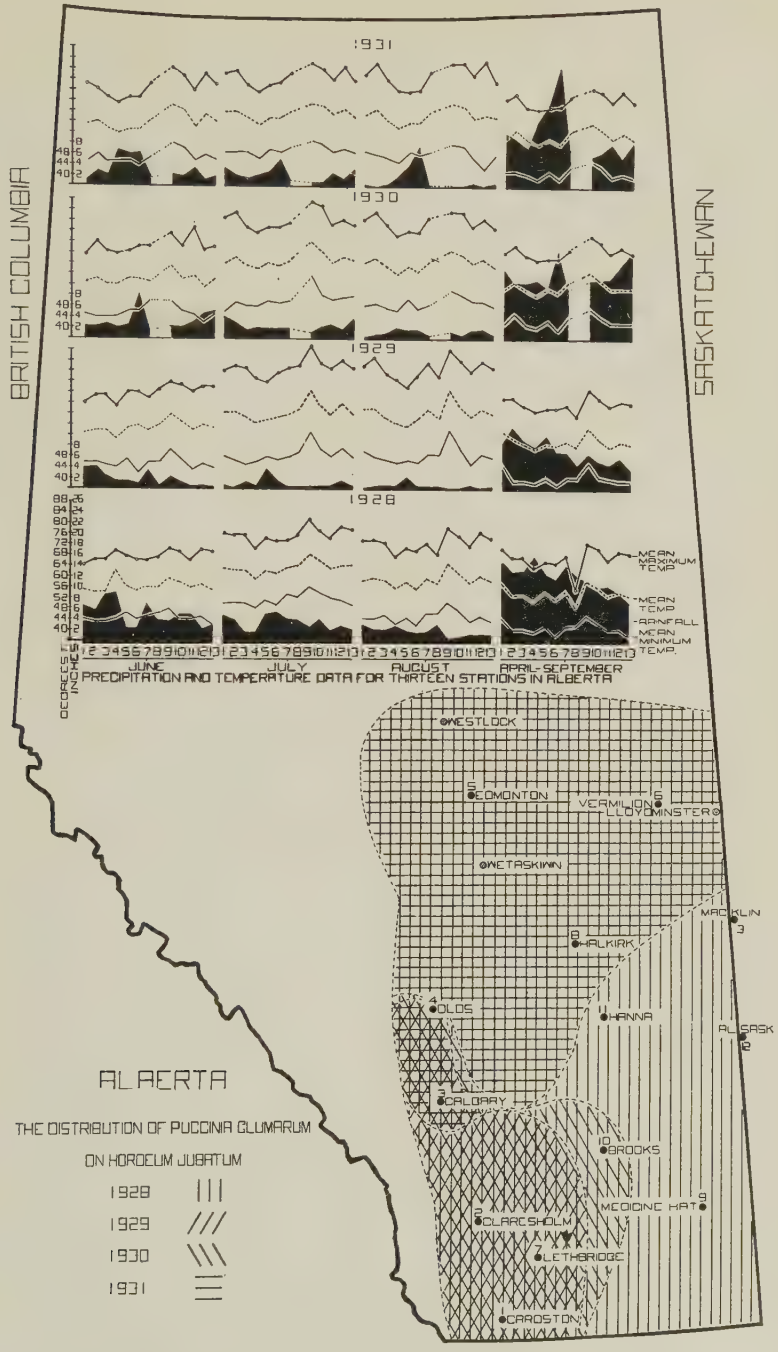


Figure 3. The general distribution of stripe rust on *H. jubatum* in Alberta, 1928, 1929, 1930 and 1931, as indicated by shading. In the charts above, rainfall and temperature data are given for June, July and August for four years.

stripe rust. Examination of the data in Tables 1 and 2 shows that in 1928 the total rainfall for six months, April to September, was distinctly more at most points in Zone I in Alberta (ranging from 11.0 to 15.8 inches) than at points in Zone III, being there about 10 inches, or much less. In Saskatchewan, that year, only at two points (Regina and Carlyle) did the precipitation slightly exceed 10 inches, while at three points it was about 9 inches and the remaining two stations, Prince Albert and Melfort about 6 inches. In 1929, when the general development of stripe rust was confined to southern Alberta (Figure 3) the precipitation in that area was generally lower (about 12 inches) than in 1928, but higher than in central Alberta, where it ranged from 10 inches at Edmonton to 7 inches at Vermilion. In Zone III the precipitation was between 4 and 6 inches. At Melfort and Prince Albert in central Saskatchewan about 11 inches were recorded, while at Swift Current and Battleford roughly 9 and 7 inches, respectively. Observational evidence is that where the rainfall was below 10 inches in Zone III, the conditions were generally unfavourable for stripe rust on the upland in 1928 and 1929. Undoubtedly the rainfall was insufficient in central Alberta in 1930 and also in Zone I in southern Alberta in 1931 for stripe rust, but favourable in central Alberta in 1931, particularly during August (see charts in Figure 3). Taking all the evidence available, both the limited development and distribution of stripe rust in Alberta, during the past four years, apparently have been distinctly restricted by conditions associated with meagre precipitation.

On the other hand, it has been observed each season that this rust makes very good headway locally during late August and September when rainfall is usually light (Table 2). This was particularly noticeable in the southern part of Zone I in Alberta in 1929 and 1930. Apparently dews are very important where the uredospores are relatively abundant and the hosts in a succulent condition. Moreover, the first collections of stripe rust have been made each year on *H. jubatum* in low, wet places, commonly called sloughs, where frequently this rust has developed to epidemic proportions and when it could not be found on the upland. Thus, indications are that sloughs in southern Alberta are important in the annual development and distribution of stripe rust. Where the first uredospores come from is unknown, but a possible source will be suggested in the section on prevailing winds.

OVERWINTERING OF STRIPE RUST

During early May, 1928, a definite case of overwintering of *P. glumarum* was found on two plants of fall sown wheat at the Provincial School of Agriculture at Claresholm (14). However, the rust soon disappeared with the death of the first leaves on which it occurred. During September, 1928, a number of rusted plants in fields of fall sown wheat, and also patches of *H. jubatum* severely rusted were marked. These were kept under close observation during May, June and July of 1929 for signs of overwintering or persistence of the rust. In the case of the winter wheat, the leaves of 1928 died before new foliage appeared and no new infections were found. In the case of *H. jubatum* the new growth came through the severely rusted dead foliage of 1928 free from rust and remained so until

early August, when it again became rusted in common with other *H. jubatum* in the locality. Similar observations were again made on wheat and *H. jubatum* for the season 1929 and 1930, with negative results. An outstanding case was a very heavily rusted field of fall wheat sown in August 1929. In May 1930 the seedling foliage was dead except on plants in a small area which had remained covered late with snow. On these plants some of the seedling foliage was fairly green, and the stripe rust lesions persisted in this. Viability tests of these uredospores gave about 2% germination. However, in spite of the reasonably moist local conditions there, for the time, no definite case of spread of this rust was found then or later during the season. Only one suspicious case of overwintering of stripe rust on *H. jubatum* has been noted, and that at Lethbridge, in May, 1930, where snow cover had been provided near an irrigation ditch.

To date there has been no indication that the recurrence of stripe rust in Alberta can be traced to the overwintering of mycelium in the living plants, or inoculum on the dead rusted foliage of these. Other tests of the possible overwintering of stripe rust from dormant mycelium were made by potting severely rusted plants of *H. jubatum* late in September, 1930. These were brought from southern Alberta to Edmonton and kept under a snow covering during the winter and then planted in the nursery, where they developed under what would appear to be very favourable climatic conditions for stripe rust. Stripe rust did not develop on these plants until September, when other hosts were also rusted. As already shown, the uredinial stage may persist on the green seedling leaves of fall sown wheat until May, providing these have been protected by a snow cover until late spring. But since these first leaves always die during May while those not snow-covered perish much earlier, it is not surprising that this rust apparently disappears under the adverse conditions for further spread or persistence. Whether moisture and temperature conditions in the low wet places (sloughs) are more favourable than on the upland for its survival is a question, but evidence to date would indicate that in general they are not. Another argument in support of this contention is that, so far, stripe rust in the sloughs of central Alberta disappears each year until late the next season. Therefore, it would seem that the recurrence of stripe rust can be explained only by the annual drifting in of uredospores, or by the presence of an alternate host about which nothing is yet known.

ANNUAL PROGRESS NORTHWARD OF STRIPE RUST

As indicated in Figure 4 stripe rust has appeared first in Alberta during July and early August in the lower part of Zone I. The first record of it has varied somewhat in the different seasons. In 1929 and 1930 it was about July 1st, while in 1931 no rust was observed until early August. The records for 1928 are not complete, inasmuch as observations for first appearance were not made during early July of that year. However, there was much evidence that stripe rust had appeared earlier than is indicated on the chart for that year. Always it was first found on *H. jubatum* growing on the edge of sloughs, or the partly dry bottoms of these places. In the south, stripe rust did not become general on the upland

until about a month after it was first noticed in the favourable places mentioned, while in the north the time between its first occurrence and when it became general was uniformly less than in the south. In 1931, the year of moderate precipitation in the north and meagre rainfall in the south, this rust still appeared first in the south, but it did not become general there. In the north, where both temperature and moisture conditions were apparently very favourable, it was extremely late in starting and slow in becoming general, not doing so until late in September. Possibly this was on account of the very meagre supply of inoculum available from southern Alberta.

On the basis of the way in which stripe rust develops, apparently Zone I could be divided roughly into a southern part, south of Calgary, where the rust develops approximately at the same time throughout, and a northern part, where its first appearance and general development have been definitely later. A possible reason for stripe rust first appearing in the south will be discussed further under prevailing winds.

EFFECT OF PREVAILING WINDS

In a letter to us about stripe rust in Idaho, Mr. W. M. Bever, of the State College of Agriculture, Moscow, said "*P. glumarum* ordinarily appears between May 1st and 15th, but is at its height between June 15th and July 10th". This suggests the theory that its regular seasonal appearance in southern Alberta in July might be traced to wind-borne uredospores carried from stripe rust areas farther south and west at that time. Such spores would produce the initial infections which are first noticed on *H. jubatum* in the low places in the south of this province during July.

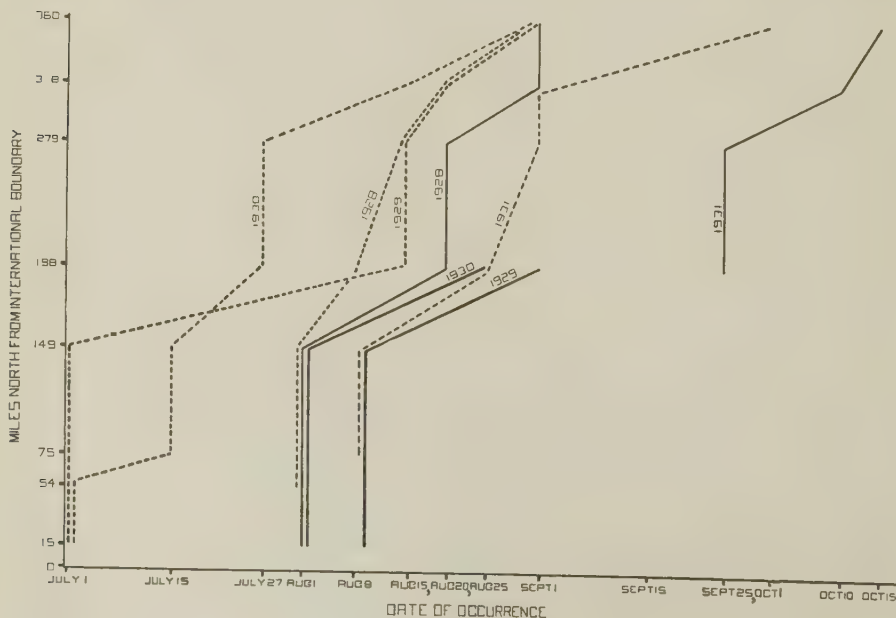


Figure 4. Showing the annual progress of stripe rust northward from the southern boundary of Alberta. Broken lines indicate first appearance, solid line general occurrence.

The direction of prevailing winds of first and second importance are given in Table 3 and indicated in Figure 2 for five stations in the states of Montana, Idaho and Washington. At the Washington points, viz. Seattle, Walla Walla and Spokane, the prevailing wind during May, June and July of 1928 and 1929 blew from the south and southwest toward southern British Columbia, while at Yakima it blew southeasterly and easterly. At Lewiston, in Idaho, and Kalispell, in western Montana, it blew westerly and southeasterly, at Helena northeasterly and at Havre northeasterly and westerly.

TABLE 3.—*Direction of winds of first and second importance, and mean relative humidity at certain points in the general stripe rust area of Washington and Montana, U.S.A.; and Alberta and Saskatchewan, Canada.*

Station	Altitude feet	Year	May			June			July			August			Sept.		
			Wind		Humidity †	Wind		Humidity	Wind		Humidity	Wind		Humidity	Wind		Humidity
			1*	2†		1	2		1	2		1	2		1	2	
Seattle	125	1928	N	S	66	NW	SW	71	NW	S	69	NW	N	70	N	S	72
		1929	S	SW	68	S	S	70	NE	S	62	NW	SW	66	N	NE	66
		1930	S	S	74	S	SW	68	NE	NE	64	NW	N	66	S	S	75
		1931	NE	SW	60	S	W	70	NE	SW	65	NE	S	67	S	SW	75
Spokane	1929	1928	S	SW	49	S	SW	48	S	N	46	S	S	39	S	SW	43
		1929	SE	SW	50	S	SW	55	SW	SW	37	S	SW	35	S	N	49
		1930	S	SW	55	SW	NW	53	S	SW	38	S	NW	38	S	S	54
		1931	SW	SW	48	S	SW	50	S	SW	36	S	S	33	S	NW	55
Kalispell	2973	1928	NW	W	55	NW	SW	67	NW	W	64	NW	SW	57	NW	NE	53
		1929	NW	NE	55	SE	SW	61	NW	W	44	NW	W	40	NW	NE	57
		1930	NW	SW	59	W	W	57	NW	SW	50	NW	NE	46	NW	NE	63
		1931	NW	SW	53	NW	SW	52	NW	SW	46	NW	W	40	NW	SW	64
Lethbridge	2933	1928	SW	NW		NW	SW		SW	SE		SW	NW		SW	SE	
		1929	SW	NW		SW	NW		SW	SE		SW	SE		SW	NW	
		1930	S	N		SW	S		SW	NW		SW	NW		SW	NW	
		1931	SW	NW		SW	NW		NW	SW		NW	SW		SW	NW	
Calgary	3428	1928	NW	SE	65	NW	NE	80	SE	NW	82	NW	SE	87	NW	SE	76
		1929	NW	SE		NW	SE		NW	SE		NW	SE		NW	NE	
		1930	NW	NW		NW	NE		SE	NW		NW	NW		NW	SE	
		1931	S	SE		W	NW		N	E		S	NW		W	W	
Lacombe	2796	1928	SE	NW		NW	NE		SE	NW		SE	SW		SE	NW	
		1929	SE	NW		SE	NW		SE	SW		SE	NW		NW	SW	
		1930	SE	NW		NW	SW		SW	NE		S	SE		SW	SE	
		1931	W	NW		W	N		W	N		W	N		W	S	
Edmonton	2158	1928			60			77			78			78			67
Swift Current	2392	1928			42			55			64			56			48
Prince Albert	1450	1928	NW	SE	79	NE	SE	85	NW	SE	85	NW	SW	88	NW	SE	84
		1929	NE	NW		NW	SE		NW	SW		NW	SW		NW	SW	

* Direction of prevailing wind at both American and Canadian stations.

† Direction of wind of maximum velocity at American stations and direction of the second prevailing wind at Canadian stations.

‡ Mean relative humidity in per cent based on 6.00 A.M. and P.M. readings at Canadian stations.

Data obtained from records of U. S. D. A. Weather Bureau and Meteorological Service of Canada.

Coming to Lethbridge, in the southwest of Alberta, the prevailing wind, particularly during May and June was from the southwest, apparently completing the wind current from the Spokane plateau. At Calgary, approximately 110 miles north and slightly west of Lethbridge, the prevailing wind was from the northwest and the wind of second importance from the southeast. The former wind would hinder the drift of spores

north into central Alberta, while the latter, coming from an area in which stripe rust develops slowly and later, would be only slightly favourable. At Lacombe, 150 miles still farther north, the prevailing winds, although more variable, were from the northwest, southeast, southwest and west, and sometimes from the south. The winds north of Calgary would be rather unfavourable for the rapid dissemination of uredospores northward from the stripe rust area farther south, which might account for the slow development of stripe rust northward, as indicated in Figure 4. In general, then, the data on wind direction indicate that the prevailing winds from the stripe rust area in Washington and northern Idaho, and the occasional wind from northwestern Montana, might carry uredospores of stripe rust into southern Alberta during June or early July, and also that unfavourable winds at Calgary and points north might retard the drift of uredospores from southern Alberta.

DISCUSSION

The possible role of overwintering of *P. glumarum*, prevailing winds, geographical location, temperature, precipitation and hosts on the incidence and subsequent spread of stripe rust in Alberta, will now be discussed briefly.

To date only two cases of overwintering of the uredinial stage of stripe rust on fall sown wheat have been observed. Evidence was that in one case the rust failed to become established again on the new foliage, and in the other instance, although some of the new foliage became slightly rusted, it shortly disappeared when these leaves died. With respect to dormant mycelium only negative evidence was obtained. If either of these sources are important under prevailing conditions, stripe rust should overwinter and appear as early in central Alberta as it does farther south, but it has consistently appeared much later.

An alternate host being unknown, and the evidence of infection from overwintered inoculum apparently negative, it would seem that the annual incidence of stripe rust might be traced to uredospores brought in by wind from the stripe rust areas of Montana, Idaho, Washington and possibly British Columbia. However, there is yet no experimental proof that stripe rust spores actually drift into Alberta from any source. Geographically, the southern part on Zone I in Alberta is relatively near the known stripe rust areas of northwestern Montana, northern Idaho, and eastern Washington, but distant from the stripe rust areas on the coast of Washington and southern British Columbia. The first area is about 200 miles away, with mountain barriers between, although the Crow's Nest Pass and the Cranbrook plateau, beyond, furnish a rather easy and direct wind route to Alberta for uredospores carried at low altitudes. The coastal areas is about 500 miles distant, with more mountain barriers, and generally unfavourable climatic conditions between during July and August. This, and the fact that stripe rust has not yet been found in Zone II of British Columbia, suggest that effective inoculum is more likely to drift into Alberta from the former area than from the coastal one, and that it does not originate in the interior of British Columbia.

An examination of the data concerning prevailing winds at points in the northern stripe rust area of the adjacent states indicates that, with the possible exception of Kalispell in northwestern Montana, the wind direction is in general very favourable for carrying uredospores into southern Alberta during May, June and July. Moreover, stripe rust is usually at its height in the former area during June and early July. The important point is what percentage of the uredospores are viable on arrival in Alberta. Raeder and Bever (13) have shown that at a relative humidity of 49% the uredospores of *P. glumarum* remained viable for 88 days at 48.2° - 55.4° F., and up to 42 days at 73.6° - 78.8°. At a relative humidity of 25% they were viable up to 63 days at 48.2° - 55.4° and for 18 days at 73.6°. The data in Table 3 suggest that the relative humidity would be reasonably favourable during May and June both at Spokane, Washington, and in southern Alberta. With regard to temperature in the line of spore-drift, we have only data taken near the ground, which would likely be warmer than at higher levels. However, the mean minimum and the mean maximum temperatures during May and June were 36.8° and 67.3°, and 43.6° and 70.0°, respectively, at Cranbrook, and 39.0° and 65.0°, and 45.7° and 70.0° at Lethbridge. These temperatures are similar to those of late August and early September, when stripe rust develops well in Alberta. It would appear, then, that relative humidity and air temperature during May and June should be reasonably favourable for the successful drift of viable uredospores from the Spokane plateau to southern Alberta.

With regard to the development of stripe rust in Alberta, observational evidence presented in Figure 4 shows that this rust has, during the years 1928 to 1931, inclusive, begun in southern Alberta during July or early August. As already mentioned, it starts principally on *H. jubatum* in low wet places. It develops more or less slowly here until the latter part of August, when, if conditions are favourable, it spreads to the upland and becomes general, and continues to spread northward until late September, when frost kills the hosts. During the past four seasons this rust has not become as abundant in the north as in the south. Since susceptible native hosts apparently are more prevalent in the north than they are in the south, it is difficult to explain the later appearance of stripe rust in the central and northern parts of Zone I, except by adverse winds during the summer months. Data in Table 3 indicate that wind directions during June, July and August were generally favourable south of Calgary in Zone I to distribute the uredospores northward throughout that area. At Calgary, however, mostly adverse winds prevail, which would tend to retard the northward drift of spores. At Lacombe, farther north, the wind, although variable and sometimes from the south, is mostly adverse, tending to blow in a southeasterly and easterly direction.

The data in Table 2 and Figure 3 would suggest that the moisture conditions in the central and northern parts of Zone I in 1931 were more favourable for stripe rust than in 1928. In the former year stripe rust developed earlier and was fairly common, but in 1931, it was not observed until late August, after which it increased very slowly. A possible reason for this is that very little stripe rust developed in southern Alberta in

1931, thus providing a scarcity of uredospores to drift north, even if favourable winds permitted them to do so. That stripe rust did not become general in the northern part of Zone I in 1929 and 1930 could be accounted for by the light precipitation during the summer months as shown in Figure 3. Apparently the temperature conditions alone could not account for the scarcity, as these were not appreciably different from those that prevailed in southern Alberta during the same seasons. Thus the amount of stripe rust each season in central Alberta may depend upon the extent to which it develops farther south.

The non-appearance of stripe rust in the central area of Saskatchewan, if such was actually the case, is difficult to explain. Perhaps the most likely reason is the late arrival and relative scarcity of highly viable uredospores from the stripe rust areas in central and southern Alberta. Although the wind from central Alberta was generally favourable for carrying uredospores eastward, stripe rust has been scarce during the past four years in this area until late August. The other source of spores would be from southern Alberta, drifting across the extensive short grass plains of Alberta and Saskatchewan (about 200 miles), a region in which stripe rust is increasingly scarce from the eastern outskirts of Zone I in Alberta, and, with few exceptions, it has not been found in the Saskatchewan portion. According to the work of Raeder and Bever (13) the relative humidity and perhaps the temperature during August in this area might decrease the germinability of wind-borne uredospores, although the data available in this connection is insufficient for conclusions. The apparent absence of stripe rust cannot be accounted for by the scarcity of susceptible hosts such as *H. jubatum*, *A. tenerum* and *A. Richardsoni*, because these are practically as common as they are in the corresponding park area of Alberta, directly west and northwest; nor on the basis of higher temperatures during July, August and early September (Tables 1 and 2), for these were not appreciably different from those in Zone I, Alberta; nor by moisture alone, for in 1930 this was apparently similar to that in southern Alberta, where stripe rust was prevalent. The lower precipitation in central Saskatchewan from April to September, 1928 and 1929, would probably be the most significant single factor in restricting the development of stripe rust there those seasons. However, the precipitation during those two years was below normal.

It should be mentioned that most of *A. Richardsoni* and *A. tenerum* are well advanced toward maturity by the end of August and are not good hosts then. Also, early frosts usually occur about this time in central Alberta and central Saskatchewan. On the other hand, in average seasons, many of the younger plants of *H. jubatum* are still green and succulent and apparently do not suffer so much from early frost. It is on these plants and on those growing in moist places that stripe rust is usually found during middle September in central Alberta. When moisture conditions are favourable and early frosts delayed, the park area of Saskatchewan would seem to offer a natural bridge for stripe rust to pass from Alberta even to Manitoba. An earlier development of stripe rust in central Alberta should increase the chances of it doing so.

Considering the evidence at hand, stripe rust does not present an economic problem in Alberta, mainly because the varieties of wheat commonly grown are, for practical purposes, resistant under field conditions, and partly because the main development of stripe rust is too late in the season. On the other hand, a rather unique opportunity is afforded to study the epidemiology of this rust in Alberta, chiefly because of geographical location, the cooler summers and the persistence of native hosts in a susceptible condition throughout summer and early autumn, and also because there is no evidence that stripe rust tends to become permanently established under prevailing conditions. The native hosts, with the exception of *H. jubatum*, do not as a rule rust heavily in nature. For this reason the latter appears to be the principal medium for the propagation and dissemination of inoculum. Whether stripe rust will eventually reach Manitoba, or having done so would have to repeat the attempt each season, time alone will decide. Present indications are that the annual incidence of stripe rust in Alberta presents a close analogy to that of *Puccinia graminis tritici* on wheat in Western Canada.

SUMMARY

The known distribution of stripe rust in Canada has been outlined and various factors of climate and hosts discussed in relation to its incidence, particularly in Alberta. Stripe rust has appeared first each year in southern Alberta during July, on *H. jubatum* in low wet places. It becomes general on the upland there, during late August, and in central Alberta, toward the middle of September. The direction of progress each year has been northward. Evidence is that stripe rust rarely persists through the winter in the uredinial stage and when it does it apparently perishes under prevailing conditions early in the spring, as the green rusted foliage dies. No evidence was obtained that stripe rust may be perpetuated from one season to another by dormant mycelium.

It is suggested that the annual appearance of stripe rust in Alberta originates from wind-borne uredospores brought into southern Alberta during June or early July from the stripe rust areas of the states of Washington, Idaho and possibly Montana. Apparently such uredospores do not originate in the central and eastern part of southern British Columbia. The late and slow development of stripe rust in central Alberta may be due chiefly to adverse winds which hinder the drift of inoculum from the southern part of the province. Evidence is that conditions associated with inadequate rainfall have been more important in restricting the development of stripe rust in certain parts of Alberta than have any differences in temperature during August and September. Dews are very important in the development of stripe rust during late August and September in Alberta.

The scarcity of stripe rust in central Saskatchewan, in a season of normal rainfall, apparently cannot be explained on the basis of temperature or of lack of susceptible hosts, for these conditions are similar to those of Zone I in Alberta, where this rust develops annually. It might be explained better by insufficient inoculum from Alberta in time to produce noticeable infection before the hosts mature or are injured by frost.

ACKNOWLEDGEMENTS

We wish to acknowledge the assistance of Messrs. M. W. Cormack and H. T. Robertson, assistant plant pathologists, with certain field data; of the Director, Dominion Meteorological Service, in supplying official records, and of the Dominion Experimental Stations at Lacombe, Lethbridge and Brooks, and the Provincial Schools of Agriculture at Claresholm, Olds and Vermilion, in planting and caring for stripe rust nurseries.

REFERENCES

- 1-6. Ann. Repts. Dominion Botanist, Ottawa, Canada; (1) 1920, p. 94; (2) 1926, p. 126; (3) 1927, pp. 48 & 112; (4) 1928, p. 55; (5) 1929, p. 87; (6) 1930, p. 66.
7. Ann. Rept. (11th) Canadian plant disease survey, Dept. of Agriculture, Canada, 1931.
8. ARTHUR, J. C. The grass rusts of South America; based on the Holway collections. Proc. Amer. Phil. 64: 131-223, 1925.
9. FRASER, W. P. and CONNERS, I. L. The uredinales of the prairie provinces of Western Canada. Trans. Royal Society of Canada 19: 279-308, 1925.
10. HUMPHREY, H. B., HUNGERFORD, C. W. and JOHNSON, A. G. Stripe rust (*Puccinia glumarum*) of cereals and grasses in the United States. Jour. Agr. Res. 29: 209-227, 1924.
11. ———, and CROMWELL, R. O. Stripe rust, *Puccinia glumarum*, on wheat in Argentina. Phytopath. 20: 981, 1931.
12. JOHNSON, T., and NEWTON, M. The occurrence of stripe rust in Western Canada. Sci. Agr. 8: 464 (abst), 1928.
13. RAEDER, J. M. and BEVER, W. M. Spore germination of *Puccinia glumarum* with notes on related species. Phytopath. 21: 767, 1931.
14. SANFORD, G. B. and BROADFOOT, W. C. Stripe rust in Alberta. Sci. Agr. 9: 337-344, 1929.

CHONDRODYSTROPHY IN FOWL EMBRYOS ¹

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INTRODUCTION

During the course of a hatchability study conducted at the Poultry Division, Central Experimental Farm, Ottawa, during the spring and early summer of 1931, the embryonic malformation known as "chondrodystrophy" was encountered.

This malformation which evidently is similar to "achondroplasia" or "chondrodystrophia foetalis" of mammals has been reported in chick embryos only at Storrs, Connecticut; Edinburgh, Scotland; and Beltsville, Maryland. The author is not aware of any published details of its occurrence at the last mentioned place while considerable discrepancy exists between the details reported by Hutt and Greenwood (5) at Edinburgh, and Dunn (3) at Storrs. It is hoped the observations made on the occurrence of this abnormality at Ottawa and herein reported, will contribute towards clarification of this contrariety. One or two new conclusions have been reached which it is hoped will furnish leads for future research.

MATERIALS AND METHODS

The hatchability study was particularly concerned with the occurrence of abnormalities gross enough to account for the failure of chicks to hatch and with the collection of data on the occurrence of such abnormalities, particularly from the standpoint of genetics. Such a study, obviously, involved the examination of dead embryos in pedigreed eggs. When the first lot of such embryos was examined, what was apparently chondrodystrophy was observed. Barred Rock and White Leghorn eggs were examined. In the former, among those dying previous to the 18th day of incubation, five out of 35 exhibited the chondro condition, while of those dying at a later stage (from the 18th to 21st days) one chondro was observed among 46 dead embryos. Of the Leghorns examined, 31 died before the 18th day and 38 after. In each of these lots only one chondro occurred.

A careful review of Landauer's (6) detailed study on the pathology and histology of the chondrodystrophic skeleton convinced us that the abnormality was identical with that reported by Dunn (2, 3), Landauer and Dunn (7) and by Hutt and Greenwood (5). A systematic examination of dead embryos from all pedigreed eggs was then undertaken. This examination which continued for several weeks, revealed 25 hens in all which produced one or more chondros during the examination period. These 25 hens consisted of 21 Barred Rocks, three White Leghorns and one Jersey Black Giant. Two of the Rocks and the Jersey Black Giant were in a pen headed by a Dark Cornish Male. The remainder were mated to males of the same breed.

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The birds were left mated as found throughout the normal hatching season of nine weeks, after which they were placed in four adjacent pens and mated to four males. Three of these males had headed pens in which more than one female had produced the abnormality, while the fourth was chosen at random from among the remaining males which had thrown the abnormality in a single mating.

All eggs laid were incubated and infertiles and dead germs (blood rings) candled out on the 7th day. The eggs were candled again on the 18th day and the dead embryos removed. All dead embryos were carefully examined, including those failing to hatch, and the sex, if distinguishable, was recorded.

DESCRIPTION OF CHONDRODYSTROPHY

An extreme chondrodystrophic embryo is markedly abnormal. The embryo in general is dwarfed. In those which have survived until practically the end of the incubation period, the absorbed yolk sac, proportionately larger than usual, gives the embryo the appearance of a ball from which the head and much shortened legs protrude. The upper beak is of normal length but, on account of the much shortened lower beak, is bent down over the latter giving the embryo the type of bill which characterizes birds of prey. These features together with the fact that, in the majority of cases, the skull is somewhat shortened in the long axis and the cranium raised anteriorly, induced Dunn (2) to tentatively term the affected embryos "parrots".

These characters range in varying degrees from the most typical of the chondros (Plate I, Figures 2 and 4) to an almost normal external appearance (Plate I, Figure 3). In the most extreme cases the legs are shortened to such an extent that the feet appear to be directly attached to the rounded body. In the younger chondros (Plate I, Figure 1) we have also noticed the retarded feather growth and the thin and somewhat curled down described by Hutt and Greenwood (5).

Landauer (6) gives a complete and detailed review of the histology of chondro-skeletons. He finds that bending of the long bones and of the tibia in particular is an almost infallible chondro characteristic. This bending which may affect the femur, metatarsus or tibia, has been used as an end point for accurate diagnosis by Landauer and Dunn (7), Dunn (3) and Hutt and Greenwood (5). It has also been used as an end point in this study in connection with those cases the external appearance of which closely approached normal.

FREQUENCY OF CHONDRODYSTROPHICS

The frequency with which the abnormality occurred among dead embryos produced by the flock as a whole during the two week period ending March 18th is given in Table 1. The proportion is higher among the embryos dying from the 7th to 17th days of incubation than among the later deaths. In Table 1 the Rocks exceed the Leghorns in producing the abnormality, and, although the numbers contributing to the computations are not large and the frequencies, therefore, none too reliable, it is believed the Leghorn stock as a whole was relatively free from the condition.

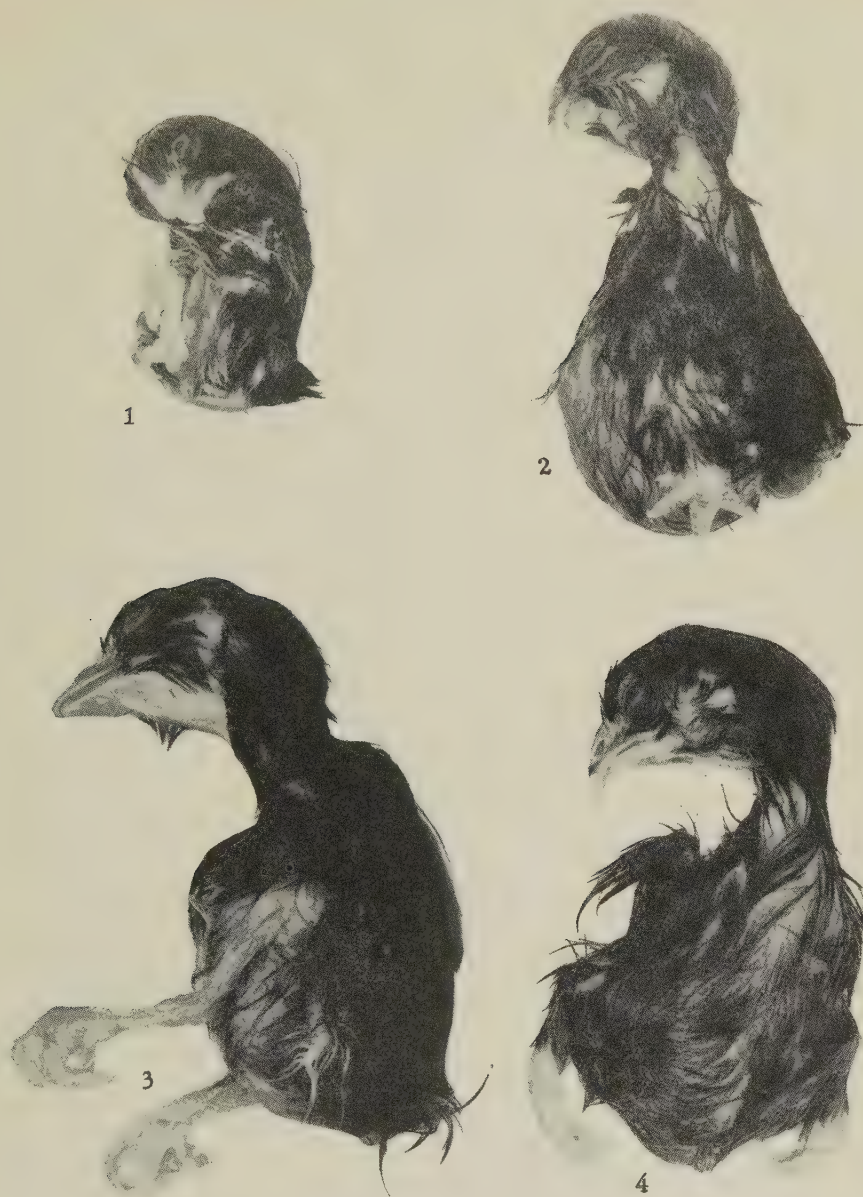


PLATE I. Photographs are natural size.

Figure 1. An extreme chondrodystrophic embryo which died about the fifteenth day of incubation.

Figure 2. A full time chondrodystrophic. Note the distended body, very short legs and almost entire absence of the lower mandible.

Figure 3. A chondro chick which hatched but which was unable to stand. The upper beak protrudes slightly and the tibia is sharply bent. The flesh has been scraped away showing the bent tibia.

Figure 4. A full time embryo exhibiting the abnormality in a degree intermediate between figures 2 and 3.

TABLE 1.—*Showing the rate of chondro occurrence throughout the flock as a whole for the two week period ending March 18th.*

Breed	Period of Embryonic Death			
	7th to 17th days		18th to 21st days	
	No. examined	% chondros	No. examined	% chondros
B. R.*	111	14.4	169	8.9
W. L.	65	4.6	94	1.1
Total	176	10.8	263	6.1

* B.R. - Barred Rock; W.L. - White Leghorn.

Chondrodystrophy occurred at the rate of 7.97% of all embryos of both breeds dying after the first week of incubation. It should be noted that these figures cover only the first two weeks of the study when the frequency of chondro occurrence, as will be shown later, was highest. It does not represent, therefore, the average rate of chondro occurrence throughout the season.

During the nine weeks in which the chondro producing females were left as originally mated, the 25 birds produced a total of 552 embryos which developed up to or beyond the stage where macroscopical examination could be relied upon to definitely detect the abnormality. Of these, 80 or 14.49% were chondrodystrophics. They were distributed according to breed as in Table 2.

TABLE 2.—*Summary of chondrodystrophics produced by original matings.*

Breeds Mated		Not Chondro	Chondro	% Chondro
Male	Female			
B. R.*	B.R.	422	59	12.26
W. L.	W.L.	21	10	31.93
D. C.	R.B.	21	9	30.00
D. C.	J.B.G.	8	2	20.00
Total		472	80	14.49

* B.R. - Barred Rock; W.L. - White Leghorn; D.C. - Dark Cornish; J.B.G. - Jersey Black Giant.

During the period May 2—June 3, during which time the same females were re-grouped and re-mated, 244 embryos were produced of which 11 or 4.51% were chondros (Table 3).

TABLE 3.—*Summary of chondrodystrophics produced after re-mating.*

Breeds Mated		Not Chondro	Chondro	% Chondro
Male	Female			
B. R.	B.R.	207	10	4.61
B. R.	W.L.	21	0	0.00
B. R.	J.B.G.	5	1	16.66
Total		233	11	4.51

Although the re-mating may be responsible, in part, for the lesser rate of occurrence in the second period, it is believed the advancing season is responsible for the greater part of the decrease. Evidence for this will be presented later.

The chondro malformation, as far as we are aware, has been reported only at Storrs, Connecticut; Edinburgh, Scotland; and Beltsville, Maryland. In connection with the latter it is merely listed by Byerly (1) as occurring at the rate of 1.1% of total dead in shell.

Although it would, therefore, seem to be of rare occurrence, it is believed a systematic search through representative samples of eggs from any flock would reveal the presence of the abnormality to a greater or lesser extent. This belief is based first, on the occurrence of the abnormality at such widely separated points as Storrs, Edinburgh and Ottawa, thus illustrating the inability of fairly wide ranges in climatic conditions to affect or at least prohibit the occurrence of the abnormality; secondly, on its occurrence in very distantly related breeds, thus showing the widespread distribution of determining hereditary factors.

The first point may be criticised on the grounds that Hutt and Greenwood (5) have shown that the occurrence of chondrodystrophy appears to be rather closely related to the season. Our evidence also supports this view. However, it is believed that the statement concerning the widespread occurrence of chondrodystrophy is justified for those seasons of the year in which the amount of sunlight is at a minimum.

The second line of evidence in support of the contention, is quite conclusive. At Storrs, Dunn (3) found the abnormality occurring in pure White Leghorn matings and in such crosses as Barred Rock \times Golden Spangled Hamburg, Silky \times Leghorn, Malay Bantam \times Leghorn and in crossbred birds carrying various mixtures of blood lines. Hutt and Greenwood (5) found the chondros in eggs laid by Brown Leghorn, White Wyandotte, Rhode Island Red, Frizzle and crossbred hens. At Ottawa the abnormality has occurred in pure Barred Rock and White Leghorn matings as well as Rock \times Leghorn, Cornish \times Rock, and Cornish \times Jersey Black Giant crosses.

SEASONAL OCCURRENCE OF CHONDRODYSTROPHY

Although Dunn (3) found a slight tendency in one group of embryos for chondrodystrophy to be linked with the season, he attached no significance to this, since his numbers were small and the season short. On the other hand, Hutt and Greenwood (5) found their 122 chondros to be rather significantly distributed over the first six months of the year. The percentage occurrence of the abnormality decreased uniformly from 34.78 in January to 0.0 in June.

The distribution of the 91 chondros found in this study supports the findings of Hutt and Greenwood. The frequency shows a steady decrease when arranged in six two-weekly periods, from 23.53% for the first period ending March 18th, to 3.48% for the sixth period ending May 27th (Table 4). A seventh period, immediately following the sixth but consisting of only one week's eggs shows an increase to 10.94%.

TABLE 4.—Seasonal distribution of chondrodystrophy by two-week periods.

Eggs Set	Mar. 11 " 18	Mar. 25 Apr. 1	Apr. 8 " 15	Apr. 22 " 29	May 6 " 13	May 20 " 27	June 3
	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.
	91 28	107 27	125 12	95 5	119 8	111 4	57 7
% Chondros	23.53	20.15	8.76	5.00	6.30	3.48	10.94

The net percentage of chondrodystrophy in Table 4 is 11.43%. Should no relation exist between the abnormality and season, we should expect its occurrence to fluctuate more or less closely about a mean rate of 11.43% in all of the seven periods. In Table 5 the observed and expected numbers are compared on this basis. On application of the χ^2 test for goodness of fit, using the method and table of Fisher (4) when n equals 7, P is found to have a value of less than 0.01. The deviation from expected is, therefore, highly significant indicating that there exists a relation between season and the rate of occurrence of chondrodystrophy.

TABLE 5.—Observed seasonal distribution of chondrodystrophy and the distribution expected if the abnormality were unrelated to season.

Eggs Set	Mar. 11 " 18	Mar. 25 Apr. 1	Apr. 8 " 15	Apr. 22 " 29	May 6 " 13	May 20 " 27	June 3
	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.	Not Chon. Chon.
Obs.	91 28	107 27	125 12	95 5	119 8	111 4	57 7
*Exp.	105.4 13.6	118.7 15.3	121.3 15.7	88.6 11.4	112.5 14.5	101.9 13.1	56.7 7.3

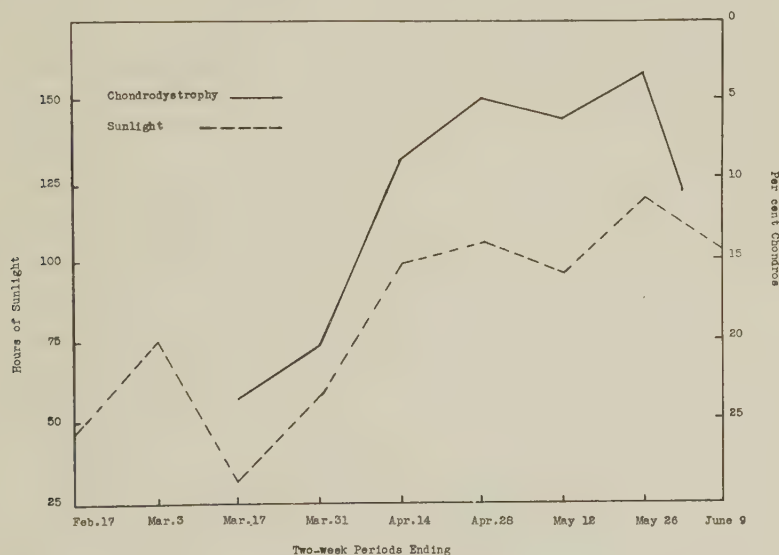
n = 7 $\chi^2 = 42.824$ P = less than .01

* on a rate of occurrence of 11.43%.

The increase in rate of occurrence during the seventh period cannot be entirely accounted for, although a possible contributing factor is discussed under the next heading. Unfortunately, it was necessary to discontinue the investigation at this point. A complete check on the occurrence of the abnormality throughout the year would be of interest and should throw some light on its apparent rhythmical occurrence.

CHONDRODYSTROPHY AND SUNLIGHT

In attempting to determine the cause of advancing seasonal decrease in the malformation, Hutt and Greenwood (5) examined the records of such climatic variants as temperature, humidity, barometric pressure and sunlight. They found that sunlight was apparently of more etiological importance than other climatic factors and that the amount of sunlight was inversely proportional to the frequency of chondrodystrophy. In order to test this hypothesis, one of the four pens of re-mated chondro-producing hens was confined indoors and the windows of the pen were completely covered with several layers of dark heavy wrapping paper. This control pen was started the middle of May after it was evident that the frequency of chondro occurrence was definitely on the decline. Unfortunately it was necessary to discontinue the investigation three weeks later. It is interesting to note however, that this control pen contributed in greater degree to the increased occurrence of the malformation which is evident during the last week, than did any one of the other three.



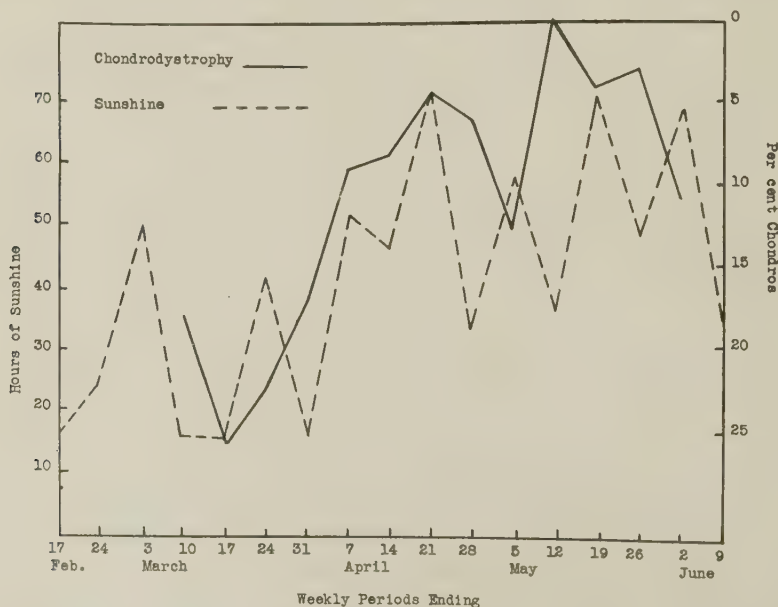
Text Figure 1. Showing the per cent occurrence of chondrodystrophy and the number of hours of bright sunshine by two-week periods.

In Text Figure 1 the per cent occurrence of chondrodystrophy is plotted by two-week periods (same periods as in Table 4). When the number of hours of sunshine as recorded by the observer at the Central Experimental Farm within half a mile of the poultry yards is plotted on the same table, it is apparent that the two are closely associated. This

supports the hypothesis of Hutt and Greenwood concerning the importance of sunlight.

From our present knowledge of the importance of sunshine in promoting normal physiological functions, we would immediately suspect ultra-violet light (vitamin D) as playing the important role. However, several things militate against the acceptance of such a theory. In the first place we would expect the decrease in chondro occurrence to lag somewhat behind the increase in sunlight. Secondly, since fowl are able to store considerable vitamin D in the body we would not expect an increase in the rate of chondro occurrence to accompany or at least to parallel a temporary drop in hours of sunshine. Thirdly, the birds were supplied a presumably complete ration containing sufficient cod liver oil to meet vitamin D requirements. In the fourth place, since the majority of the birds were confined indoors until May without access to direct sunlight except for a short time on fine days when the windows of the pens were removed, it is improbable that they received from the sunshine sufficient vitamin D to prove effective.

Since Figure 1 indicates that increases and decreases in the rate of chondro occurrence depend on, and actually accompany decreases and increases respectively in sunshine, it was thought advisable to plot similar curves on a weekly basis in order to measure more precisely the closeness of parallelism apparently existing. This has been done and is presented in Text Figure 2. Up until the middle of April this chart shows nothing more than a general decrease in chondro frequency associated with a general increase in hours of sunshine. Beginning the latter part of April however, and following through May and the first of



Text Figure 2. Showing the per cent occurrence of chondrodystrophy and the number of hours of bright sunshine by weekly periods.

June, an increase in amount of sunshine is followed next week by a decrease in rate of chondrodystrophy, similarly a decrease in amount of sunshine is followed by an increase in the frequency of chondrodystrophy. Figure 2 thus discloses a lag of one week which is not apparent in Figure 1. If the decrease in the abnormality were due to vitamin D received in the sunshine we should not expect (on account of the birds' ability to store vitamin D) decreases in the amount of sunlight to be followed in a week's time by increases in chondro frequency.

On the whole the evidence would indicate that sunlight plays an important role either directly or indirectly in chondro occurrence. If this role is a direct one the evidence indicates the existence of bands in the spectrum which play an important but hitherto unknown role in physiological processes.

CHONDRODYSTROPHY AND SEX

Dunn (3) reported the sex of 51 chondros, 26 being males and 25 females. Hutt and Greenwood (5) determined the sex of 83 chondros and found 50 to be males and 33 females. Of 91 normal embryos from the same hens of the same period, the latter authors found 41 males and 50 females. They observe that on first sight the males appear significantly high in the chondros and proportionally low in the normals. However, on application of the χ^2 test for goodness of fit they found the value of P to be 0.107 and the deviation from expected, therefore, not necessarily significant.

In this study it has been possible to definitely distinguish the sex of 78 chondros. Of these 50 were males and 28 females. A total of 261 dead embryos other than chondros which were produced by the chondro hens during the same period were definitely sexed, 98 being males and 163 females. The sex ratio of the total of 339 embryos from the chondro hens is found to be 77.49 when expressed as males per 100 females. The number of males and females expected on this basis among the chondros and those not afflicted with the malformation as well as the observed numbers in each class are given in Table 6. Upon application of the χ^2 test for goodness of fit to these data we find the value of χ^2 to be 17.334 and P much less than 0.01. The deviation of observed from expected is therefore highly significant and it is evident that a chondrodystrophy sexually selective mortality exists which takes its toll on the monogametic sex.

TABLE 6.—*Distribution of the sexes observed among chondro embryos and those not chondros and the distribution expected on a sex ratio basis of 77.49.*

	Not Chondros		Chondros	
	Males	Females	Males	Females
Observed	98	163	50	28
Expected	114	147	34	44
n = 2	$\chi^2 = 17.334$		P = less than 0.01	

A sex ratio of 77.49 appears low, but a considerably larger population of dead embryos from the general flock was sexed during the hatching season and the ratio on this population is in very close agreement with that given above. Indeed, we are inclined to believe a prenatal sexually selective mortality exists, which takes its toll on the heterogametic sex. Since this is not in agreement with some previously reported work as well as the general consensus of opinion it is hoped to secure more extensive data bearing on this point in the near future. At this moment it is sufficient to state that should the sex ratio of the larger population be used as the basis for the expected numbers in Table 6, the deviation of observed from expected would be even greater.

To test further whether the chondrodystrophic condition is sexually selective the numbers of males and females found among chondro embryos by Dunn at Storrs, Hutt and Greenwood at Edinburgh and the author at Ottawa are given in Table 7, together with the numbers expected if the two sexes were subject to neither prenatal nor chondrodystrophic sexually selective mortality (i.e., a 1:1 ratio basis).

TABLE 7.—*Actual sex distribution observed among chondro embryos by different authors, together with expected distribution on a 1:1 ratio basis.*

	Dunn		Hutt & Greenwood		Present Series	
	Males	Females	Males	Females	Males	Females
Observed	26	25	50	33	50	28
Expected	25.5	25.5	41.5	41.5	39	39
n = 3	$\chi^2 = 9.706$		P = slightly greater than 0.02			

The χ^2 test for goodness of fit here reveals a value for P of between 0.02 and 0.05. Even here then, the deviation from expected is significant especially when we consider that the value of P is much nearer 0.02 than 0.05.

Since our expected basis in Table 7 is simply a 1:1 ratio we can calculate a probable error for the grand totals of the two sexes in this table by applying the probable error formula for such a ratio ($P.E. = .6745\sqrt{p.q.n.}$, when p and q are the elements of the ratio and n the number of individuals). When the deviation to which the probable error applies is expressed in absolute numbers, the formula resolves itself into $.6745\sqrt{.50 \times .50n} = \sqrt{.1137n}$. In our case with a number of 212 the probable error = 4.91. The deviation from expectancy which is 20 is 4.07 times the probable error. This means that only once in approximately 160 repetitions would one expect as poor a fit or worse. The deviation is therefore highly significant and the probable error test confirms that of the χ^2 .

Chondrodystrophy, therefore, exhibits sexual selection, a statistically significant excess of males being afflicted with the malformation.

THE LETHAL NATURE OF CHONDRODYSTROPHY

From their own observations, as well as those of Dunn (3), Hutt and Greenwood (5) were led to assume "that chondrodystrophic embryos do not hatch but usually die before 19 days." In the extreme chondrodystrophic cases, the formation of the legs and beak would practically prohibit hatching. However, we might expect that those chondros which approached quite closely to the normal condition might occasionally hatch. In such cases, unless each individual was histologically examined, they might even escape detection. In this study two individuals which emerged from the egg entirely unaided were definitely diagnosed as chondrodystrophics. These chicks were both cripples, being unable to gain their feet. In one case the chondro condition was immediately noticeable on gross examination, both tibia and femur being sharply bent while the beak also exhibited the chondro condition to some extent. This individual was kept alive for nearly two weeks by hand feeding milk and beef broth. The chick was unable to open its mouth of its own accord and the mandibles could be opened to only a very limited extent by hand. Not even the end of a small pipette could be inserted and the chick finally died from lack of nourishment.

The chondro condition was less evident in the other case, although the appearance of the chick led to a close examination of the long bones of the leg which revealed a bend in the tibia (Plate I, Figure 3). This individual also lived for a short time but, being unable to stand and move about, soon perished.

DISCUSSION

In attempting to assign a cause to the occurrence of chondrodystrophy, we are immediately confronted with the lack of specific information. That it is definitely related to environmental conditions is shown by its relation to season and to sunlight. In a broad way then, the problem that confronts us is two fold. First, what particular environmental factor or combination of factors is concerned in the production of the malformation and secondly, does its appearance also depend on hereditary factors.

It is true that, in a sense, environmental relationships cannot be properly investigated without adequate control of possible genetic factors. However, since the existence of these are not certain, while that of environmental factors is already established, it is evident that investigations concerning the nature of the latter, using as material mated pairs whose progeny have already exhibited the abnormality, is the most logical course to pursue.

In regard to the second question, that of the hereditary factors, it is evident that the reliability of the results of such an investigation must await more definite controls which can be established only after the environmental relationships are better understood.

While the existence of genetic causes is not certain, several lines of evidence point to such. In the first place, as pointed out by Dunn (3) corroborated by Hutt and Greenwood (5) and as also established by the

author, the occurrence of chondrodystrophy is definitely related to certain hens. In the second place, chondrodystrophy shows segregation; the offspring from chondrodystrophic matings are for the most part normal but contain periodically occurring chondros which indicate gene recombinations. In the third place, the relation of chondrodystrophy to sex while apparently not being a case of sex linkage might still be reconciled to such if we concede that potential chondrodystrophics appear normal in many cases. At any rate the abnormality appears in some way to be related to the male complex which in itself would indicate other than environmental determiners.

From the standpoint of genetics, chondrodystrophy might be due to the genotype of the dam or to the genotype of the embryo itself. If the former were the sole cause, the abnormality would be expressed in the embryo, not through the particular genes chancing to occur in the gamete but, presumably, in the indirect way of determining the chemical constituents of the food substances of the egg. If this were so, and since the food substance in all eggs of one dam is derived from genotypically similar soma, we should expect all eggs from the same dam to contain the same defect in chemical constitution. All embryos developing from such eggs should be defective and definite segregation should not occur.

On the other hand, the results obtained by Dunn (3) militate strongly against genetic recombinations as a causal factor. However, as Dunn himself states, "The distribution of chondrodystrophy among the descendants of the inbred 'chondro' family, irregular and rare as it is, might still be reconciled with the theory of inheritance if the hereditary basis of chondrodystrophy were not a single factor but either a combination of several recessive factors or a general hereditary background determining susceptibility to external or internal conditions which disturb development."

Hutt and Greenwood (5) were led to believe "that the causal agency is an hereditary physiological abnormality in the dam, which, under certain environmental conditions, results in the production of chondrodystrophy in the embryo."

The evidence as a whole indicates that an heritable basis plus certain unfavourable conditions results in phenotypical chondrodystrophy.

SUMMARY

Chondrodystrophy is described and during the early part of the hatching season was found among the flock as a whole to cause approximately 8% of the embryonic deaths occurring after the seventh day.

The frequency of chondrodystrophy is definitely related to the season. Its frequency declined from 23.53% during the first part of March to 3.48% the latter part of May.

Sunlight appears to be of considerable etiological importance. The effect of sunlight on the chondro condition may be either direct or indirect and apparently follows with a lag of approximately one week.

Indications point to a factor or factors other than vitamin D in sunlight as playing the important role.

The chondro condition is shown to be definitely sexually selective, more males than females being afflicted with the malformation.

It is possible for the less extreme chondrodystrophic embryos to hatch and it may be possible for them to survive for a considerable period, perhaps even to maturity.

It is pointed out that the evidence is strong for believing the malformation to be due to genetic factors which depend on unfavourable environmental conditions to become phenotypically expressed.

Evidence is discussed to show that such an hereditary basis is not a simple recessive, although the evidence might still be reconciled with a monofactorial basis if the abnormality were dominant, but not expressed under very "favourable" conditions.

On the whole the evidence indicates that the abnormality depends primarily on a more or less complex hereditary base and secondarily on a strategic combination of environmental conditions both physical and physiological.

LITERATURE CITED

1. BYERLY, T. C. Time of occurrence and probable causes of mortality in chick embryos. Proc. 4th World's Poul. Cong., 178-186, 1930.
2. DUNN, L. C. The problem of hatchability from the standpoint of genetics. Sci. Agr., 4:1-7, 1923.
3. ——— The occurrence of chondrodystrophy in chick embryos. 11. The genetic evidence. Roux' Arch. f. Entwick d. Org., 110 Bd., 2 Heft, 341-365, 1927.
4. FISHER, R. A. "Statistical methods for research workers." 3rd ed., pp. 1-283, Oliver and Boyd, London, 1930.
5. HUTT, F. B., and A. W. GREENWOOD. Studies in embryonic mortality in the fowl. 1. Chondrodystrophy in the chick. Proc. Roy. Soc. Edin., 49. Part 2, 131-144, 1928-29.
6. LANDAUER, W. Untersuchungen über Chondrodystrophie. 1. Allgemeine Erscheinungen und skelett chondrodystrophischer Hühnerembryonen. Roux' Arch. f. Entwick d. Org., 110 Bd., 2 Heft, 195-282, 1927.
7. Landauer, W., and L. C. DUNN. Chondrodystrophia in chicken embryos. Proc. Soc. Exp. Biol. Med., 23: 562-566, 1927.

BOTRYTIS TULIPAE (Lib.) Lind.

II. BULB DIPS.

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Some of the local commercial growers dip their tulip bulbs in solutions of mercuric chloride, organic mercury compounds, formalin, or other disinfectants before planting, but few are convinced that the practice plays an important part in the control of "tulip fire", *Botrytis tulipae* (Lib.) Lind. In the first paper of this series (1) we suggested that protection from conidial infection is probably the most important factor in the control of this disease, and we showed that low temperatures and unfavourable conditions for growth stimulated the production of conidia. These experiments supported our field observations that after periods of cold wet weather the spread of tulip fire was particularly rapid. The dipping of the bulbs in disinfectants is probably a minor factor in the control of the *Botrytis* disease owing to the small amount of infection that reaches the bulbs even when the foliage becomes severely infected during the growing season. In 1931 over 4000 bulbs were examined from a field where the foliage of all the plants was severely infected and only 1.5% of the bulbs were found bearing sclerotia, or other evidence of infection. The importance of sanitary measures was revealed by a spring examination of over 300 flowering stalks. Without exception every stalk carried a few to



Figure 1.

- A. Dead tulip stems bearing large numbers of sclerotia. B. An individual sclerotia bearing a tuft of fruiting mycelium.

several thousand viable sclerotia. At the time of examination a great number of these sclerotia bore tufts of fruiting mycelia. Although the destruction of the foliage debris, the early removal of infected plants, rotation and other cultural practices are of major importance, undoubtedly a suitable dip treatment is of some importance in the control of the *Botrytis* disease.

EXPERIMENTAL

Sclerotia developed on agar media were immersed in disinfectants for one hour at approximately 20°C., and then transferred to sterile agar plates. The minimum concentration of each disinfectant that killed the sclerotia, as indicated by their failure to germinate, is recorded in Table 1 under "dosis curativa":

To determine the toxicity of the same disinfectants to tulip bulbs, sound uniform Clara Butt bulbs were immersed for one hour, at approximately 20°C., in each disinfectant at variable concentrations. All were planted in five inch pots, three bulbs to a pot. Before planting, the pots and soil were sterilized at 15 lbs. steam pressure for two hours, and subsequently half of the pots were inoculated by heavy seeding with viable sclerotia. Although concentrations of the disinfectants were used, three to six times the "dosis curativa", in few cases was plant injury very conspicuous. When injured areas were found on the shoots greater than one mm. in diameter the concentration was assumed to have reached the toxic point and these concentration values are recorded in Table 1 under "dosis tolerata".

TABLE 1.

Disinfectant	Dosis curativa %	Dosis tolerata %	Ratio or margin of safety
Formalin (40% formaldehyde).....	0.3	0.6	2.0
Mercuric chloride.....	0.03	0.1	3.3
Uspulun.....	0.5	1.5	3.0
Semesan.....	1.0	1.5	1.5
Copper sulphate.....	6.0	4.0	Minus
Potassium resin polysulphide (2).....	<6.0*	2.0	Minus

*The sclerotia germinated after being immersed in a 6% solution of this spray material described in the cited (2) publication.

It is apparent from the ratio "dosis tolerata" to "dosis curativa" that mercuric chloride and uspulun are the most satisfactory disinfectants, for the bulbs were not significantly injured until a concentration was reached three times that which was required to kill the sclerotia. On the other hand, copper sulphate and the potassium resin polysulphide spray material were toxic to the bulbs at the concentrations required to kill the sclerotia.

Residual effect of the disinfectants

All the bulbs planted in soil inoculated with viable sclerotia were examined five days and twenty days after sprouting for *Botrytis* infection

on the sprouts injured by the dips. The percentages of plants infected are recorded in Table 2.

TABLE 2.—*Botrytis* infection on shoots exhibiting injury as the sequence of the one hour bulb immersion.

Disinfectant	Percentage of shoots infected	
	5 days	20 days
Formalin.....	80%	100%
Mercuric chloride.....	0	0
Semesan.....	0	0
Uspulun.....	5	5
Copper sulphate.....	10	10
Potassium resin polysulphide.....	0	0

The data in Table 2 suggest that sufficient of the mercury compounds, mercuric chloride, semesan and uspulun, are absorbed to increase the resistance of tulip plants against *Botrytis* infection during their early growth period, and indicate on the other hand that formalin has no residual effect. Although for practical use copper sulphate and the polysulphide compound are too injurious to the vitality of the bulbs at concentrations sufficient to kill the sclerotia, nevertheless, these substances appear to increase to a degree the resistance of plants to *Botrytis* infection.

Owing to the small number of bulbs exhibiting injury, less than thirty for each disinfectant, these conclusions are not final. The experiment was repeated on a larger scale in the field.

THE RESIDUAL EFFECT OF DIPS AND DUSTS AND THE INFLUENCE OF DEPTH AND SYSTEM OF PLANTING

Ten plots of tulips repeated four times, or a total of forty plots of one hundred bulbs in each, were planted October 5, 1931, to determine the residual effect of dips and dusts and the influence of depth and system of planting upon the incidence of *Botrytis* infection in the field. The bulbs were dipped for one hour at room temperature after removing the outer brown skins. The dip concentrations in every case were greater than that required to kill the sclerotia but in no case was the concentration greater than the "dosis tolerata". All the plots were heavily infected at the time of planting by scattering over the soil surface large quantities of sclerotia-bearing flower stalks.

A summary of the results is given in Table 3. The data indicate that no dip or dust entirely prevents early spring soil borne infection, but the results support our conclusion derived from the greenhouse experimental data recorded in Table 2, namely, that mercuric chloride, semesan and uspulun are apparently absorbed in sufficient amounts to lower the incidence of infection. The data in Table 3 also confirm the conclusions of Abbiss (3) that deep planting lowers the incidence of infec-

tion. Our results failed to reveal a significant difference between the bed and flat system of planting.

TABLE 3.—*The influence upon the number of diseased plants of (A) dip and dust treatments; (B) depth of planting; (C) system of planting.*

Treatment	Diseased plants		Total Number diseased	Total percentage diseased
	Found and eliminated 8 3-32	Found and eliminated 20-3 32		
A. DIP AND DUST TREATMENT:				
Formalin dip.....	9	5	14	3.5
Hg Cl. 2 dip.....	5	2	7	1.7
Semesan dip.....	5	1	6	1.5
Uspulun dip.....	5	4	9	2.2
Sulphur dust.....	9	5	14	3.5
K Mn O ₄ dip.....	11	5	16	4.0
Bordeaux dust.....	14	3	17	4.2
Semesan dust.....	7	4	11	2.7
Uspulun dust.....	All plants severely injured by this dust treatment.			
Untreated.....	9	6	15	3.7
B. DEPTH OF PLANTING:				
Five inches deep.....	49	23	72	3.6
Eight inches deep.....	27	16	43	2.1
C. SYSTEM OF PLANTING:				
Bed system of planting.....	31	23	54	2.7
Flat system of planting.....	45	16	61	3.0

SUMMARY

1. The ratio of the "dosis tolerata" to "dosis curativa" with respect to a one hour dip treatment indicates that mercuric chloride and uspulun are superior to semesan and formalin and that copper sulphate and potassium resin polysulphide are unsuitable dips, the ratios being minus values.
2. In a greenhouse experiment, mercuric chloride, semesan and uspulun increased the resistance of shoots against soil borne infection, but formalin exerted no such residual effect. A subsequent field experiment verified this conclusion. Mercuric chloride, semesan and uspulun dips reduced the incidence of soil borne infection to a greater degree than the formalin dip and a number of dust treatments. Deep planting, eight inches compared with four, lowered the incidence of infection, but the bed compared with the flat system of planting exerted little significant effect.

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REFERENCES

1. NEWTON, W. AND R. J. HASTINGS. *Botrytis tulipae* (Lib.) Lind. I. The production of conidia as influenced by various factors. *Sci. Agr.* 11: 820-824. 1931.
2. ———. "A New Sulphur Resin Spray". *Sci. Agr.* 11: 26-28. 1930.
3. ABBISS, H. W. Annual Report of the Gulval Experimental Station, Cornwall, England. 1929-30.

THE PREPARATION OF A GENETIC SOIL MAP OF CANADA ¹

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Although soil scientists, especially those interested in soil classification, are agreed in general as to the application of the word "genetic" to soil classification and mapping, it might be well in introducing the subject for the author to state his conception of these terms.

Genesis or mode of development is, of course, the central idea; and a genetical soil classification would therefore be one which, although based on actual soil characteristics, at the same time reflects the major factors responsible for the development of these characteristics. In other words, the various classification groups established and the areas of soils mapped would have a direct relation to the fundamental factors of soil development, namely, climate, native vegetation, parent materials, topographical position, natural drainage and degree of maturity.

Actually any classification based on the natural characteristics of the soil profile would be genetic because the chemical, physical, and biological characteristics evidenced in the various horizons are but an expression of the changes which have taken place in the natural development of the soil from its parent material in a given natural environment and the fact that a genetic soil classification is based on actual soil character makes it obvious that one of the first points which must be agreed upon in initiating the proposed project is the degree of detail to be used in mapping. It is the author's opinion that in our first attempt at a Canadian genetic soil map we would limit ourselves to the higher categories of classification, particularly to those classification units determined by the influence of the greater natural environment factors, climate and native vegetation, except in cases where the other fundamental factors exert a stronger influence and the areas affected are comparable in size to the larger groups.

To be more specific, in Saskatchewan for example, this first map would outline such broad zonal groups of soils as our gray podsollic soils, the darker degraded chernosems, the deep dark chernosems, the shallow dark chernosems, the chestnut brown transition soils, etc. In addition we would map a number of large areas of very sandy soil such as the Great Sand Hills, of very heavy textured soils such as the Regina and Sceptre clay belts, and of our so-called "burnt-out" soils (solodi and solonetz) of our Echo and Radville Series.

In terms of the formal genetic classification scheme outlined by Nikiforoff (1) and described by Ellis (1) we would in general limit ourselves to the mapping of Zones or possibly to Combinations. In addition, particular combinations, associations or members of other lower cate-

¹Except for some revisions and additions, this paper is essentially the one given at a meeting of the Soils Group at the C.S.T.A. Convention at Winnipeg, June 16, 1932, at the request of the Chairman of that group. At a later business meeting the author was requested to appoint a standing committee to work on the project. It is hoped that this committee will be able to present the first tentative genetic soil map of Canada at the next annual meeting of the Soils Group.

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gories would be mapped in cases where extensive area and the strong influence of non-zonal factors warranted making these exceptions.

In terms of the classification suggested by Marbut (2) and used in his tentative soil map of the United States, we would limit ourselves in general to his categories IV and V. These categories include such broad groups as podsols, brown forest soils, North Temperate Pedocals, etc.

Such a map would be similar in principle and detail to soil maps already produced or being attempted in a number of other countries and sponsored by the International Society of Soil Science.

With such a map as a basis we could at any time in the future, as progress in classification and mapping in Canada warranted it, proceed with a second genetic map of greater detail. For example, a second map could later be made to show soil areas associated with parent materials (the Association of the Nikiforoff system). Some of the provinces, at least, will likely be in a position to proceed with such a map within the next decade.

CHART 1		KEY FOR FIELD CLASSIFICATION OF SOILS IN A UNIT AREA.			THE NIKIFOROFF SYSTEM
Soils in the Zone of the		Determined by Common Morphological Characters of the Phytomorphic (Well drained) Associates, or the Typical Normal Soils of the Zone.			
A. Combination of Soils in a given physio- graphic region	B. Associations Differentiated on the basis of Parent Material (Geological)	Associates.			
		C ₁ Oromorphic (Eroded or Locally Arid)	C ₂ Phytomorphic (Well drained)	C ₃ Hydromorphic (Poorly drained, or Locally Humid)	
		D ₁ D ₂ etc.	D ₁ D ₂ etc.	D ₁ D ₂ etc.	
		* Sub-divided into phases as they occur.	* Sub-divided into phases as they occur.	* Sub-divided into phases as they occur.	
	B ₁ B ₂ B ₃ B ₄ B ₅ etc.	* A phase is a variation or modification of an associate which differs in some characteristic but with other Associate Characteristics in Common. Associates and Phases, further differentiated according to textural Classes			

Chart 1. The Nikiforoff system of field classification of soils.

The need for genetic soil maps, not only for Canada, but for other countries is almost self evident. The various International Soil Conferences have recognized their scientific importance and provided machinery in the way of committees and commissions to promote them. At the Prague Conference (3) in 1922, a committee was appointed which worked on this proposition and at the Rome Conference (3) which followed it, a committee recommended "that soil specialists in all countries be urged to accumulate data, each in his own country, that may serve for the construction of a reconnaissance soil map, and transmit this to the chairman of certain committees to be organized for that purpose, one for Europe and Asia, and another for the Americas, in order that these committees may prepare, for presentation to the Fifth International Congress of Soil Scientists, such map as the data will permit." In fact, at the First International Congress of Soil Science, (referred to as the Fifth above) held at Washington in 1928, a tentative zonal genetic map was prepared

by Wyatt, Ellis and Joel for the Canadian Prairie Provinces and presented at a meeting of the Fifth Commission. Papers were also given by Wyatt and Newton (4) and Joel (5), describing zonal profiles and environmental conditions in Alberta and Saskatchewan.

Canada covers an appreciable proportion of the earth's surface and includes within its boundaries a great variety of soil types. The following genetical groups of soil, at least, have been investigated to some extent: podsoles, brown forest soils, northern chernozem, normal chernosem, rendzinas, meadow soils, degraded chernosems and rendzinas, chestnut brown plains, grayish brown semi-arid plains, solonetz and solodi, various types of salines and various types of peats. In consideration of these facts alone a Canadian genetic soil map would undoubtedly be a worth while contribution to soil science and considering the many practical applications which have been made of the tentative zonal soil map of Saskatchewan, I feel sure that a Canadian genetic soil map would also be well worth while from a practical as well as a scientific standpoint.

The Soils Group, it seems to me, is the proper body and probably the only body that is able to effectively work on such a proposition. It is the only organization in this country that is composed largely of soil specialists, and the only organization that will provide a forum for considering our soil problems with a national viewpoint and that will enable us to throw our full weight behind matters in which soil propositions are of major importance. Interest in soils was never greater in Canada than it is today, and never in the past has the outlook for effective organization been more promising. Another argument for our attempting this project is that it will provide us with a definite problem to work on. A satisfactory soil classification and a satisfactory soil map are really necessary as a foundation for much of the work of soil science in future years. We must know the character of our soils and have them conveniently classified before we can intelligently investigate them or apply our knowledge, and a definite problem in which most of us are interested is the type of stimulus needed by this group to ensure its progressive growth. I am sure the chairman of the group had this in mind when he invited me to present a paper on this subject.

We must, of course, recognize that there are serious difficulties in the way, at least in the way of completing the map within a reasonably short time. In the first place, soil surveys on an extensive scale are not being conducted in a number of the provinces. The prairie provinces and Ontario have done considerable work and British Columbia and Quebec are apparently working up a good stride. But when we consider that these provinces include by far the larger part of the area of the country which is suited to agriculture, the situation is quite hopeful. The work already done in these provinces, if co-ordinated and properly used, might easily become a strong influence to promote extensive soil surveys in the other provinces. And when extensive soil survey programs are planned for these provinces, the zonal or broad-scale, genetic map should be the first product, as reconnaissance surveys logically precede detailed surveys in a soil survey program intended to cover regional areas.

Another handicap is that at present we lack sufficient uniformity in systems of classification. However that is not as serious as it might appear to be. There seems to be general agreement as to viewpoint and principles of classification, and there should be no insurmountable difficulties to prevent the working out of a harmonious and workable scheme of classification if the interested parties get together and struggle with the matter. Agreement on classification, at least in principle, would be one of our first aims in attempting to work out a genetical map. In this connection, I would suggest that we use the established genetical soil groups, especially those of Russia, the United States, and Canada until an acceptable international classification is established or until we work out an acceptable one of our own.

There are other difficulties, some no doubt as serious as the ones discussed. General curtailment of programs as the result of the present economic crisis and the lack of a Dominion division or department of soils to lead the way in correlating soil types and in co-ordinating provincial efforts are two which must be considered. However, as the project under discussion must necessarily be considered a long-time proposition, the above mentioned difficulties should be considered merely as obstacles to be gradually overcome and not as unsurmountable difficulties.

There are at least two considerations which make me think that one of the first desirable steps toward the promotion of the project of making a genetic soil map of Canada would be the appointment of a standing committee to work actively on the proposition. In fact, at present I hesitate to go any further than to recommend that such a step be taken. I have in mind a committee similar to one of the many committees of the American Soil Survey Association, an organization which has made excellent progress and accomplished many worth while things in the comparatively short period of its existence.

In the first place a comparatively small group of men composed of individuals greatly interested in such a map, and with a fund of information to apply directly to it, would be almost sure to make the most of the available knowledge which could be applied to the undertaking. The intention is not to eliminate the Soils Group from the proposition by any means, but to have this committee work actively during the year and present their condensed proposals and recommendations to the annual meeting of the group and possibly in the annual reports and keep the matter active and going.

In the second place the project must necessarily take a number of years, and therefore the committee should be appointed for an indefinite time with provision for replacing members as it is found desirable. In fact, I daresay that it will be a never-ending job for soil classification is still a young thing and we will no doubt revise and add to our Canadian soil map indefinitely. A standing committee such as proposed above seems to be the only means of handling a proposition which will be in the nature of continuous development and never really reaching perfection.

SOME SUGGESTIONS FOR PROMOTING THE PROJECT

As a conclusion to the paper I should like to make the following suggestions and shall be pleased to have the whole proposition thoroughly discussed from the standpoint of considering the proposal as a project for the Soils Group.

1. That an active committee composed of men particularly interested in such a project give the matter special attention. There should be at least one member from each province, and the representation from each province should give particular attention to correlating classification units and soil boundaries with those of adjoining provinces.
2. That during the period between now and the next convention maps be submitted from each province to the chairman of the committee for the purpose of combining these maps into a preliminary soil map of Canada, to be presented at the next annual meeting of the Soils Group.

Until an uniform classification is agreed upon for Canada as a whole, the categories suggested in the early part of the paper, or broad categories similar to them, could be used. In provinces in which very little work has been done in the way of a genetical classification of their soils, the best classification and map available should be presented as a starting point even if it is very general in character.

3. That a fair proportion of the program of the next annual meeting of the group be devoted to a full discussion of the project, particularly the matter of a classification for general use in Canada. It is hoped that out of such a discussion we may agree on a form of classification from which we may proceed to build up our map from year to year, adding to it as we get the desired information and revising it to take advantage of newer knowledge and changing viewpoints.
4. That the project be considered a long-time proposition and that the committee therefore be standing in order to insure continued progress in the adding to and revising of the Canadian genic soil map. Changes in personnel of the committee should, of course, be made when advisable.

LITERATURE CITED

1. ELLIS, J. H. A field classification of soils for use in the soil survey. *Scientific Agriculture*, 12: 338, 1932.
2. MARBUT, C. F. A scheme for soil classification. *Proc. First Int. Congress Soil Sc.* 4, 1927.
3. ——— Outline of a scheme for the study of soil profiles. Issued in typed form previous to First Int. Congress Soil Sc. 1927.
4. WYATT, F. A. and NEWTON, J. D. Alberta soil profiles. *Proc. First Int. Congress. Soil Sc.*, 4. 1927.
5. JOEL, A. H. Predominant soil profiles correlated with soil development factors in northern latitudes. *Proc. First Int. Congress Soil Sc.*, 4. 1927.

SEEDLING HAIRINESS AS A VARIETAL IDENTIFICATION CHARACTER IN WHEAT¹

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Varietal analysis of wheat samples is made by means of seed examination or by growing tests. Seed examination is usually satisfactory for separating seeds of the different species commonly grown in Canada such as durum and common, but it is of doubtful value for separating seeds of varieties of common red spring wheat since one cannot be very certain that a given seed belongs to a given variety. The only accurate procedure now in use is the making of a growing test in which each plant goes on to maturity. Frequently it is highly desirable to have definite information on the varietal content of a sample of wheat seed at short notice and the wait of several months until a growing test is made is inconvenient and expensive. On the plains of Western Canada very few wheat varieties are used and the bulk of the acreage of common spring wheat is sown to only four varieties. An accidental discovery led to a fairly sure method of separating two of these in the seedling stage. Since a seedling test can be made in eight or nine days, it would be of much value if it made accurate varietal separations possible.

Seedling hairiness has been used in the identification of wheat species for some time. Percival (3) in his wheat monograph shows that the type and distribution of the hairs on the surface of young leaves can be used as a species differentiating character. Miczynski (2) found the same thing with respect to the genus *Aegilops*. He describes six types of hairiness involving different combinations of length, frequency and location of hairs. In an Australian wheat variety classification by Archer (1) seedling character is used in the key to species but is not mentioned in the variety descriptions.

EXPERIMENTAL PROCEDURE

In the fall of 1930 the writer noticed that two day old seedlings of several varieties of common wheat used in some greenhouse investigations differed with respect to hairiness. These differences were clearly observable with the naked eye when strong sunlight fell upon the seedling leaves. When a hand lens was used it was found that the principal differences were in the number, length and distribution of the hairs on the upper surface of the leaves. Owing to the possible value of these differences as an aid in breeding and in seed purity tests, a preliminary study of seedling characters was planned.

The preliminary study was made upon 26 varieties of common and durum wheat. It was started by sowing 30 seeds of a bulk lot of each variety in greenhouse pots according to the usual procedure. Only a few varieties were sown at a time so that ample time was afforded for a careful examination of the seedlings. Some varieties differed from the

¹The various tests reported in this paper were entirely of a preliminary nature and were not intended as an exhaustive study. The results have attracted some attention; consequently, they are presented here for whatever use they may be.

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³Or about one hundred days in the case of a winter progeny test in the greenhouse.

others in coleoptile pigmentation but the differences in hairiness were most noteworthy. Each seedling was examined by sunlight and by a hand lens about two days after emergence. As the temperature of the greenhouse was between 65° and 70°F. and as the seed were sown less than an inch deep the seedling examination was usually made within eight or nine days of the time of planting. The varieties used were all of spring habit and included 25 common wheats (*T. vulgare*) and 8 durums (*T. durum*). In addition, 9 strains of Marquis wheat were examined.

At the conclusion of the preliminary study a tentative identification key was drawn up, the characters used being seed shape, seed color, coleoptile pigmentation and the amount, length and distribution of hairs on the upper and lower surface of the first seedling leaf. To test this key many different lots of seed were made up, each lot being a mixture of two or more varieties. Each seed of each collection or lot was separately enveloped under a letter the varietal identity of which was known only to the person making up the collections. An attempt was then made by the writer to identify each seed as to variety. The seeds were sown and a third person attempted to identify each seedling as to variety using the tentative key as a guide. On the basis of the results of the various tests the key was amended.

RESULTS

Varietal identification on the basis of superficial examination of single seeds proved of little value where the mixtures contained different varieties of the same species and seed color. A preliminary test was made as follows: A series of 64 single seeds of 16 different varieties of common wheat (from samples averaging Grade 2N) were separately enveloped and given separate identification letters by one individual. A list showed the correct variety name for each letter. Another person knowing nothing of the identity of the seeds excepting the names of the 16 varieties used in the test, attempted to identify them. There were 17 correct answers and 47 incorrect ones. However, this test was entirely theoretical and much more severe than anything that would arise in ordinary commercial work. Further tests were made in which the mixtures were similar to those that are found in wagon lots, elevators and cargoes. Sixty per cent of the seed identifications in these tests were correct. Very frequently it was impossible to state that a given seed belonged definitely to this, that or some other variety.

Coleoptile coloration proved of some value as an identification character. Four varieties, H-44, Hope, Kitchener and Ruby, all showed a reddish tinge on the coleoptile. This was fairly constant and reliable under the greenhouse conditions used but might vary under other conditions. A few seedlings of these varieties failed to show the coloration. These may have resulted from natural crosses.

The number of main nerves or vascular bundles in the seedling leaves varies but the varietal differences were not very constant owing to the amount of variability within many of the varieties. This character, therefore, was not used in the identification of individual seedlings.

The cilia or marginal hairs on the seedling leaves were found to vary in number, size and length on different varieties. But in view of the

various differences in the hairiness of the upper leaf surface, the cilia character was not recorded.

Seedling hairiness proved of distinct value in the separation of Reward from Marquis and of value in some other varietal separations. In many cases, the differences between varieties were too small and the variations in hairiness too large to make highly accurate identifications possible. After a considerable amount of work a preliminary key was drawn up for the description of some 25 common red seeded spring wheat varieties with respect to seedling hairiness and coleoptile pigmentation. This key does not contain the ten durum wheats which were studied. The durumms were almost hairless, the hairs present being very minute and there was no difficulty separating *durum* seedlings from *vulgare* seedlings. The key also omits the various Marquis strains since they were found to be closely alike in seedling hairiness.

PRELIMINARY KEY TO SEEDLING IDENTIFICATION OF WESTERN CANADIAN WHEAT VARIETIES.

A. Coleoptile with reddish tinge.

B. Usually three rows of hairs per ridge of the inner surface of the seedling leaf; hairs medium to long, many. H-44, Hope

BB. Usually one row of hairs per ridge; hairs few.

C. Hairs short Ruby

CC. Hairs very short Kitchener

AA. Coleoptile without redish tinge.

B. Usually three rows of hairs per ridge.

C. Many hairs.

D. Hairs short to medium Preston, Garnet

DD. Hairs medium to long Ceres, Ladoga

DDD. Hairs of center row longest, coarse Kota

CC. Few hairs.

D. Hairs short Red Fife, Stanley, Prelude,
Marquillo, Early Red Fife.

DD. Hairs medium to long Reward

BB. Usually one row of hairs per ridge.

C. Hairs many.

D. Hairs long Axminster

DD. Hairs short Vermilion

CC. Hairs few, mostly short Marquis, Reliance, Renfrew,
Early Triumph, Supreme,
Red Bobs, Huron.

At the conclusion of the 64 seed preliminary identification test each seed was sown and labelled with its designating letter and a third person made seedling examinations. Owing to the impossibility of exact varietal identification where so many varieties were mixed, the identification was made according to variety groups. The varieties were considered for this purpose to fall in three general groups with respect to seedling hairiness and coleoptile color. The results showed 29 seedlings placed in the correct variety groups and 20 incorrectly placed.

Further tests were then made, and in these the mixtures usually included only two or three different varieties. The results of a series of ten

tests are given in Table 1. It is significant that 92 out of 122 seedlings were correctly identified as to variety. In all cases the person making the identifications did not know which varieties, out of a group of thirty, were used but he did know that no one test included more than three varieties. It will be of interest to mention the high points of these tests:

Test No. 1. In a mixed lot of Marquis, Reward and Garnet, there was no instance in which Marquis was mistaken for Reward or vice versa. Some Marquis seedlings were mistaken for Garnet and some Garnet seedlings were classified as Reward.

Test No. 2. Ruby and Kitchener were separated remarkably well considering that they are alike in hairiness excepting for a minute difference in hair length.

Test Nos. 3 to 7. These tests show the unreliability of seedling hairiness character for the separation of a number of varieties.

Test No. 8. Ceres and Garnet were identified unusually well considering that they only differ a trifle in hair length.

Test No. 9. This is a perfect separation of Garnet from Marquis in contrast with Tests Nos. 1 and 6.

Test No. 10. Garnet and Kota were perfectly separated.

Another test was made in which 106 seeds of the varieties Marquis, Reward and Garnet were sown under key numbers, and seedling identification made by an assistant who previously had had no contact with this work. The 106 seeds were sown on July 18th in two lots of 53 each, one (Test No. 11) in the greenhouse in five inch pots, ten seeds per pot, and the other 53 (Test No. 12) in the field. Examination of the seedlings grown in the greenhouse was made on July 25th and of the field group on July 26th. A total of 53 seedlings emerged in the greenhouse test and 41 in the field test. The results are shown in Table 2.

The seedlings of Test No. 11 were examined while in the pots, which made close comparison with known check cultures difficult. There were 9 incorrect identifications but none of them were between Reward and Marquis. In Test No. 12 each seedling was held beside a check culture seedling for examination. This procedure and the experience gained in the first test made for greater accuracy and there were only three errors. Considering both tests, only one Reward seedling out of a total of 82 was identified as Marquis and no Marquis seedling was considered to be Reward. The percentage of incorrect identifications in the second test was 92.7%. Considering that most stocks of non-registered standard varieties contain fully two or three percent of off-types, it would be unreasonable to expect a seedling identification test to show a greater accuracy than 97 or 98%.

These tests indicate possibilities for the use of the seedling stage as a follow up in the analysis of seed samples. Figure 1 illustrates the method of examination and shows the difference between Marquis and Reward. All of the tests reported in the tables were made by sunlight. Most of the examinations were made with a small hand lens with the leaf held so that the hairs reflected the sunlight into the operators' eyes. The operator had previous to this study, no experience in such work. A stronger lens, an especially arranged light and background and an experienced

TABLE 1.—*Results of a series of seedling identification tests.*

Test No.	Varieties represented	Variety Identification								Totals	
		Marq.	Gar.	Rew.	Ruby	Kit.	Kota	R.F.	Ceres	Correct	Wrong
1	Marquis Garnet Reward	16	3 11	3 9						16 11 9	3 3
2	Ruby Kitchener				16 1	4 7				16 7	4 1
3	Marquis E. R. Fife Kota	2 1 2					1			2 1	1 2
4	Red Fife Ceres	2					1	3		3	2 1
5	Red Fife Kota	2					3	1		1 3	2
6	Garnet	5	1							1	5
7	Kota Garnet Ceres	1 1	1				1 1			1 1	1 2
8	Garnet Ceres		4 2						1	4	1 2
9	Garnet Marquis	2	6							6 2	
10	Garnet Kota		5				3			5 3	
	Totals									92	30

TABLE 2.—*Varietal identification of seedlings by an assistant without previous experience in the work. (July, 1932).*

Variety	Identified as	Number of Seedlings	
		Test No. 11	Test No. 12
Marquis	Marquis	25	21
Garnet	Garnet	14	11
Reward	Reward	5	6
Total correct		44	38
Marquis	Garnet	3	0
Garnet	Marquis	1	0
Garnet	Reward	3	1
Reward	Garnet	2	1
Marquis	Reward	0	0
Reward	Marquis	0	1
Total incorrect		9	3
Grand Total		53	41
Percentage correct		83.1	92.7

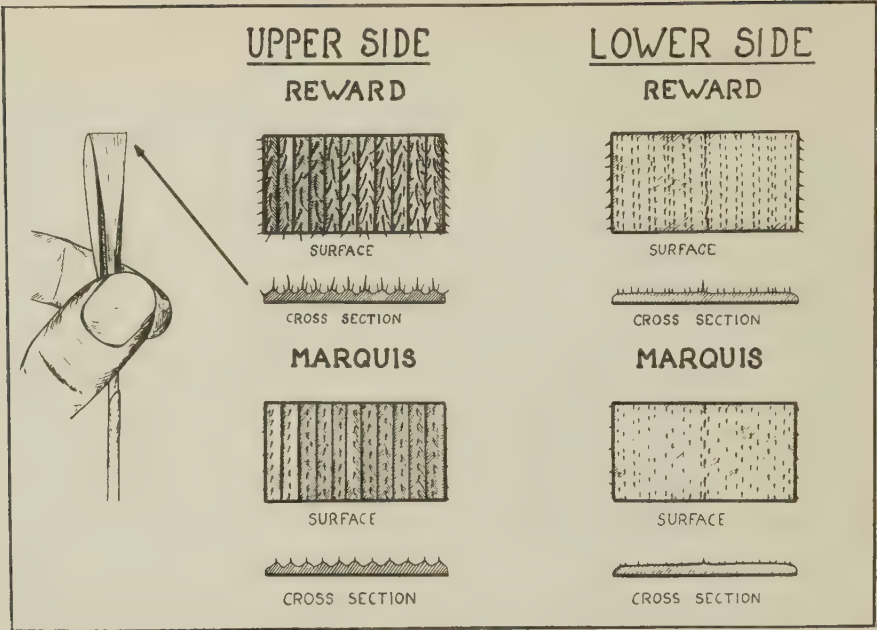


Figure 1. The method of holding a seedling leaf for sunlight examination of its hairiness, and magnified surface and cross sections of seedling leaves of Reward and Marquis.

operator would be the combination necessary for commercial seedling tests.

DISCUSSION

The identification of the different varieties in seed samples and commercial lots of wheat is of extreme importance in Canada. From the offering of seed for sale to the arrival of Canadian wheat cargoes in Europe, the Canadian Government and numerous private individuals and agencies are vitally interested in the varietal make-up of the different lots of wheat. The seed branch analysts, federal grain inspectors and private individuals have to depend almost wholly upon an examination of the seed itself. The sittings of the Select Standing Committee on Agriculture and Colonization of the House of Commons, in connection with the grading of Garnet wheat showed that federal grain inspectors could make remarkably good separations of Garnet from other varieties in seed mixtures on the basis of seed examination. Yet the varietal identity of any single seed is not known definitely until a growing test has been made.

The present study, while of limited scope and of a preliminary nature has shown that the seedling stage may be used as an aid in the varietal analysis of wheat samples. Marquis and Reward, the two most highly recommended varieties of the northern settled districts of Saskatchewan and Alberta and excepting for Garnet, the only two important varieties of that area may be separated accurately at the seedling stage by means of their differences in leaf hairiness. The difference between the varieties is clearly shown in the illustration and is observable in seedlings on the day of emergence from the soil. The seeds of these two varieties are closely similar in general size, shape and color. There are small but distinct differences between Marquis and Reward which serve to identify pure samples

of either but the variability among the kernels of both varieties makes the complete separation of the two varieties in a mixed sample a practical impossibility.

As far as the federal grain inspection department or a grain buyer is concerned, a mixture of Marquis and Reward is of no importance since these varieties are fairly similar in milling and baking characteristics. But from the viewpoint of a seed inspector, seed merchant or farmer, a mixture of Reward and Marquis is quite undesirable. Reward is about a week earlier in maturing than Marquis and in disease reaction, soil preference and other characters is quite unlike Marquis. The federal seed branch and private individuals desire to know if either Marquis or Reward contains an admixture of the other and to what extent. Field inspection (which constitutes a growing test of the parental stock) is used for the seed purchaser's protection in the case of certified or registered seed but there is no further highly accurate test whereby, before the next season³, the varietal nature of a given seed stock may be checked up. The seedling test offers a method for checking Marquis and Reward for reciprocal mixtures.

The fact that a seedling test may be made within eight days is of particular importance. The standard germination tests made by the Dominion Seed Branch on wheat usually require ten days. The time required for a given carload of wheat to be hauled from a central Saskatchewan point and delivered into an elevator at the head of the Great Lakes is often eight days. In either case, a seedling test of a sample could be completed quickly enough to be of practical value as an aid in settling a doubtful point respecting the varietal nature of the sample.

SUMMARY

1. A study was made of the possible value of seedling characters in the identification of wheat varieties.
2. A preliminary key of western Canadian hard red spring wheat varieties was made with respect to the characters coleoptile coloration and seedling hairiness.
3. It was found that Marquis and Reward seedlings could be separated accurately within a day of emergence.
4. Other separations such as Marquis from Garnet and Garnet from Reward were less successful.
5. The possibilities of the seedling hairiness test for use in the seed and grain trade are discussed.

ACKNOWLEDGMENTS

The writer acknowledges with appreciation the careful work of Mr. Norman Langhorne, who made most of the seedling examinations, and wishes to thank Mr. George Godel for his kindness in making the enlarged drawings of Figure 1.

LITERATURE CITED

1. ARCHER, ELLINOR. A classification and detailed description of the more important wheats of Australia. Comm. Australia, Inst. Sci. and Indus. Bul. 26. 1923.
2. MICZYNSKI, C. Notes systematiques sur le genre *Aegilops*. Bul. Soc. Botan. France 66, 5th Ser Vol. 5: 713-719. 1929.
3. PERCIVAL, JOHN. The wheat plant. Duckworth & Co. London. 1921.

³Or about one hundred days in the case of a winter progeny test in the greenhouse.

THE GIZZARD WORM IN QUEBEC¹

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Examination of poultry in the vicinity of St. Annes in 1923 disclosed the presence of round worms invading the walls of the gizzard of a mature Rhode Island Red bird. In 1929 similar worms were found in S.C. White Leghorn stock in a poultry plant near Dorval. In 1931 further records were obtained from Beaconsfield (B. Plymouth Rock bird) and Baie d'Urfe (S.C.W.L. bird).

Considerable damage to the gizzards of birds infected with these worms was noted and the parasites were usually partly hidden within tunnels formed in the walls of the muscular layers. Necrotic areas were to be observed in the mucus membrane of the gizzard with some loosening of the lining.

The above parasites have been identified as *Cheilospirura hamulosa*, commonly known as the gizzard worm of chickens and turkeys. This round worm is recorded as having an indirect life history and that its intermediate hosts are grasshoppers. The worms are round, from one quarter to less than an inch in length, and frequently found coiled within the gizzard wall of their host.

Weakening of the gizzard wall may occur due to the action of the parasites, which may give rise to external sac-like formation arising in the organ. This extension may become quite excessive and the rupture of the gizzard has been recorded. These parasites may cause injury sufficient to bring about the death of the bird.



The gizzard worm. *Cheilospirura hamulosa*, in the wall of the gizzard of the domestic fowl.

¹Part of Animal Parasite Investigation at Macdonald College receiving financial assistance from the National Research Council of Canada.

²Professor of Animal Pathology.

RECORDS OF DISTRIBUTION OF INTERNAL PARASITES OF POULTRY IN THE PROVINCE OF QUEBEC ¹

ALEX. D. BAKER ²

Macdonald College, McGill University, P.Q.

[Received for publication April 10, 1932]

INTRODUCTION

Definite records of the distribution of parasites of domestic animals in this country are rather meagre. The present paper represents an effort to place on record some points in the Province of Quebec where the various species of internal parasites of poultry have been located.

All examinations of birds were made directly at the indicated locality from which a parasite is recorded. Care was taken that the birds autopsied had been raised in the immediate vicinity and were not just recent importations. All records are those of the writer, except where otherwise noted.

For the sake of brevity it has been found necessary to exclude date of capture and breed records. The data were secured during 1929 and (or) 1930, except as directly indicated.

RECORDS OF DISTRIBUTION

Eimeria avium (Rivolta & Silvestrini, 1873) (spp.)

While it is recognized, owing to the work of Dr. Tyzzer of Harvard, that the species of fowl coccidium formerly called *Eimeria avium* in reality includes at least three species, for the purpose of field examinations it was found expedient to employ the older grouping. The caecal type of coccidial infection was located in practically all the listed localities.

Distribution records:—

Montmagny.	Beauharnois.	St. Felix.
L'Islet.	Chateauguay.	Berthierville, east.
Valleyfield, west.	Papineauville, north.	St. Elizabeth.
Huntingdon.	St. Andre Avellin.	Rawdon.
Howick, north.	Cote St. Pierre, south.	Joliette.
St. Mathieu, south.	Arundel.	Granby.
St. Mathieu.	Thurso.	Hemmingford.
St. Stanislas.	Lake Megantic.	St. Anne de Bellevue.

Ascaridia lineata (Scheider, 1866) Railliet & Henry, 1912.

The large roundworm inhabiting the small intestine of fowls. Easily distinguished from the caecal worm (*Heterakis gallinae*) by its greater size, in the adult stage, and by the absence of a posterior bulb to the oesophagus.

Distribution records:—

Montmagny.	Longueuil.	Thurso.
L'Islet.	Beauharnois.	Masson.
St. Anicet, SW.	St. Andre Avellin.	Campbells Bay.
Howick, north.	Arundel.	Quyon.
Brosseaux Station.	Lachute, 5 m. south.	Quinnville.

¹Part of Animal Parasite Investigation at Macdonald College receiving financial assistance from the National Research Council of Canada.

²Entomologist and Parasitologist, Macdonald College.

Alcove.
Beebe, 8 m. NW.
Lennoxville.
St. Anne de Bellevue.

St. Hyacinthe.
St. Felix, 2 m. north.
St. Felix.

St. Elizabeth.
Granby.
Hemmingford.

Heterakis gallinae (Gmelin, 1790) Freeborn, 1923.

Small, white, somewhat rigid roundworms with a well developed posterior bulb to the oesophagus. Anterior end of worm usually strongly bent dorsad. Worms usually found in the caeca, particularly at the distal extremity, but sometimes they may occur in other portions of the intestine posterior to the gizzard.

Distribution records:—

Montmagny.
Montmagny, St. Francois.
Montmagny, north.
Montmagny, de la Grave.
Montmagny, south river.
L'Islet.
St. Anne de la Pocatiere,
St. Anne de la Pocatiere,
north.
St. Anne de la Pocatiere,
south.
Covey Hill.
Hemmingford.
Valleyfield.
Valleyfield, north.
Valleyfield, west.
Huntingdon, Boyd's Sett.
St. Anicet.
Between Ormstown and
Baysons.
Howick, north.

St. Michel, east.
St. Mathieu.
St. Stanislas, south.
St. Martine.
Beauharnois, west.
Chateauguay.
Brosseaux Station.
Longueuil.
Papineauville, north.
St. Andre Avellin.
Cote St. Pierre, south.
Val Quesnel.
Arundel.
Lachute, 5 m. south.
Calumet.
Thurso.
Masson.
Shawville, 4 m. SE.
Campbells Bay.
Quyon.
Rawdon.

Granby.
Quinnville.
Alcove.
Beebe.
Beebe, 8 m. N.W.
Aylmer.
North Hatley.
Lennoxville.
Lake Megantic.
Lake Megantic, 8 m. north.
St. Ludger.
St. Hyacinthe.
Sorel.
St. Anne de Bellevue.
Joliette.
St. Felix.
St. Felix, 2 m. north.
Berthierville.
St. Elizabeth.
Hemmingford.
St. Stanislas.

Capillaria meleagris-gallopavo (Barile, 1912).

Very fine thread-like worm. Usually found with anterior end deeply buried in the intestinal wall of the host. Have been observed to be sometimes associated with hard thickened regions in the intestinal walls. Eggs of these worms are lemon-shaped, with opercular plugs at each end.

Distribution records:—

Montmagny.
L'Islet.
Valleyfield, west.

Quinnville.
Alcove.
Berthierville.

St. Elizabeth
Hemmingford.
St. Anne de Bellevue.

Cheilospirura hamulosa (Diesing, 1851) Diesing, 1861.

Parasites of the gizzard. Usually found in small fleshy growths on the surface and in the wall of the gizzard.

DESCRIPTION OF FIGURES ON OPPOSITE PAGE

Figure 1. The Triangular Tapeworm, *Amoebotaenia sphenoides*. One of the microscopic tapeworms of fowls. Greatly enlarged.

Figure 2. Head of the Slender Tapeworm, *Hymenolepis carioca*. Enlarged.

Figure 3. Segments of one of the large tapeworms of fowls, *Railletina cesticillus*. Enlarged.



FIGURE 1.



FIGURE 2.



FIGURE 3.

See foot of opposite page.

Distribution records:—

St. Anne de Bellevue. (R. L. Conklin, 1923).	Beaconsfield. (R. L. Conklin, 1931).	Baie d'Urfe. (R. L. Conklin, 1931).
Dorval. (R. L. Conklin, 1929).		

Amoebotaenia sphenoides (Railliet) Cohn.

A microscopic tapeworm inhabiting the small intestine. Body composed of 15-24 segments. Entire worm frequently presents a triangular appearance.

Distribution records:—

Montmagny.	Campbells Bay.	St. Anne de Bellevue, (R. L. Conklin, 1931).
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Davainea proglottina (Davaine, 1860) Blanchard, 1891.

A microscopic tapeworm inhabiting the small intestine. Body composed of 2-7 segments. The ripe segments separate readily from remainder of worm and are longer than broad.

Distribution records:—

Montmagny.	Beauharnois, west.	Alymer.
Hemmingford.	Papineauville, north.	North Hatley.
Valleyfield.	St. Andre Avellin.	Lake Megantic.
Huntingdon, south-west.	Arundel.	St. Hyacinthe.
Between Ormstown and Baysons.	Calumet.	St. Anne de Bellevue.
St. Michel, east.	Campbells Bay.	Berthierville.
	Alcove.	Granby.

Raillietina (*Skjabinia*) *cesticillus* (Molin, 1858).

A large stout tapeworm inhabiting the small intestine. Head broad and flat and with suckers not as conspicuous as *Choanotaenia infundibulum*.

Distribution records:—

Montmagny.	St. Michel, east.	Quyon.
St. Anne de la Pocatiere,	St. Andre Avellin.	

Hymenolepis carioca (Magal. 1896) Ransom, 1902.

Long slender tapeworm inhabiting the small intestine. Head without prominent hooks. Easily distinguished from the other large species of tapeworm, by its fine delicate appearance. Infestations usually heavy.

Distribution records:—

St. Anne de la Pocatiere,	Lachute.	Quyon.
St. Andre Avellin.	Masson.	St. Felix.
Arundel.	Shawville, 4 m. SE.	St. Felix, 2 m. north.

Choanotaenia infundibulum (Goeze, 1782), Railliet, 1896.

Large stout tapeworm inhabiting the small intestine. Head with large conspicuous suckers and an armed beak. Readily distinguished from *R. cesticillus* by the head structures.

Distribution records:—

St. Anicet.	Lachute, 5 m. south.	St. Hyacinthe.
Val Quesnel.	Quinnville.	St. Anne de Bellevue.
Lachute.	Alcove.	

RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

EPIDEMIOLOGIE DE LA ROUILLE LINEAIRE DANS L'OUEST DU CANADA. Par G. B. Sanford et W. C. Broadfoot, Laboratoire fédéral de Pathologie Végétale, Université de l'Alberta, Edmonton.

Les auteurs indiquent la distribution connue de la rouille linéaire au Canada et discutent plusieurs facteurs concernant notamment le climat et les plantes qui donnent asile à cette maladie. Celle-ci s'étend du sud au nord de l'Alberta et apparaît chaque année sur des plantes indigènes. Il semble que la maladie ne puisse pas résister à l'hiver. Les auteurs suggèrent qu'elle peut provenir de spores venant de régions infectées des Etats-Unis et apportées par le vent dans le sud de l'Alberta. La maladie est très rare dans le centre de la Saskatchewan, vraisemblablement parce qu'il n'y a pas assez de spores mûries en Alberta pour infecter la Saskatchewan.

CHONDRODYSTROPHIE DES EMBRYONS DE VOLAILLE. Par S. S. Munro, Ferme Expérimentale Centrale, Ottawa, Ont.

L'auteur décrit une malformation des poussins avant l'éclosion qui cause environ 8% des morts embryonnaires survenant après le septième jour. Le pourcentage baisse de 23.53% au début de mars à 3.48% à la fin de mai, la quantité de lumière étant probablement responsable de cette condition. Cette malformation semble avoir des causes héréditaires complexes et dépendre aussi du milieu.

BOTRYTIS TULIPAE (Lib.) Lind. Par W. Newton, R. J. Hastings et J. E. Bosher, Laboratoire fédéral de Pathologie Végétale, Saanichton, B.C.

Pour contrôler la maladie des tulipes appelée "*Botrytis tulipae*" les auteurs ont trempé les bulbes pendant une heure dans divers désinfectants de concentrations variables. Le chlorure mercurique et l'uspulun se sont montrés supérieurs au semesan et à la formaline. Le sulfate de cuivre et le polysulfite-résine de potasse se sont montrés inefficaces. L'infection est moindre quand les bulbes sont plantés à 8 pouces au lieu de 4 mais il n'y a pas de différence entre les plantations à plat et les plantations en planches.

PREPARATION D'UNE CARTE GENETIQUE DES SOLS DU CANADA. Par A. H. Joel, Université de la Saskatchewan, Saskatoon, Sask.

A la deuxième réunion de la Section des Sols de la C.S.T.A. tenue en juin à Winnipeg, l'auteur a été chargé de former un comité devant préparer une carte génétique des sols du Canada. Cet article expose brièvement le besoin d'une telle carte et les bases générales sur lesquelles elle devrait être préparée.

LA PILOSITE DES JEUNES PLANTES DE BLE COMME CARACTERE D'IDENTIFICATION DES VARIETES. Par J. B. Harrington, Université de la Saskatchewan, Saskatoon, Sask.

L'auteur décrit une méthode par laquelle on peut reconnaître quelques-uns de nos blés de printemps par l'examen de la pilosité des feuilles des jeunes plantes. Une clef a été établie basée sur la coloration de la coléophylle et sur la pilosité des jeunes feuilles. Les blés Marquis et Reward peuvent être séparés avec précision moins d'une jour après l'apparition de la plantule au-dessus du sol. Ce système est susceptible d'une grande importance pratique en permettant aux inspecteurs de grain de vérifier les variétés expédiées par chemin de fer en un temps plus court que par aucune autre méthode connue. Les essais réguliers de germination faits par la Division fédérale de Semences demandent généralement dix jours. La méthode décrite permet de vérifier les variétés des expéditions faites par chemin de fer du centre de la Saskatchewan avant que le grain soit arrivé aux éleveurs à la tête des grands lacs.

LE VER DU GESIER. Par R. L. Conklin, Macdonald College, Université de McGill, P.Q.

L'auteur décrit la première apparition de ce parasite dans la Province de Québec.

LA DISTRIBUTION DES PARASITES INTERNES DES VOLAILLES DANS LA PROVINCE DE QUEBEC. Par A. D. Baker, Macdonald College, Université de McGill, P.Q.

Ceux qui s'intéressent à cette question sont invités à entrer en communication avec l'auteur.

CURRENT PUBLICATIONS

PRINCIPLES OF SOIL MICROBIOLOGY. Selman A. Waksman, Professor of Soil Microbiology, Rutgers University, and Microbiologist, New Jersey Agricultural Experiment Stations. Second Edition, thoroughly revised. The Williams and Wilkins Company, Baltimore, 1932. Pp. xxviii—894, pl. xv, 83 text figs. \$10.00.

The appearance of the first edition of Waksman's *Principles of Soil Microbiology* in 1927 marked an epoch in the history of this branch of soil science, which was in urgent need of such an authoritative, comprehensive work which would assemble the scattered data and present our knowledge of the subject in the form of an unified whole. The work was acclaimed by soil scientists the world over, and its translation into the principal foreign languages is but evidence that the author has given a work which has filled an universal need.

The second edition will be equally welcomed by soil scientists in general and by workers in the field of microbiology in particular. It represents a complete revision, while in addition several chapters have been entirely rewritten and a number of chapters added. As indicated in the preface, the author has tried to avoid any increase in the actual size of the book (about 900 pages). To keep within the same confines, he has not only added such material as the developments of the past five years have necessitated, but has also condensed in certain chapters to maintain for the several divisions of the subject an allotment of space in keeping with a properly balanced survey of the whole field at the present state of knowledge.

Comparison with the first edition shows the second edition to contain two more chapters, or 34 in all. These are divided into four main parts as follows: (a) occurrence and abundance of microorganisms in the soil; (b) isolation, identification and cultivation of soil microorganisms; (c) chemical activities of microorganisms; (d) soil microbiological processes and soil fertility. To the subject matter of the last-named part more attention is devoted in the new edition in over 60 additional pages. These are accounted for by the new chapters treating of the part played by microorganisms in the decomposition of organic matter, of the formation of peat and forest soils, and of the relation between growing plants and the activities of soil microorganisms. It is to these phases of the subject that much recent research has been devoted, and the new chapters will be specially welcomed as forming an up-to-date summary of our knowledge.

Recognition of the activities of organisms other than bacteria proper is evident throughout the volume which devotes ample space to such groups as soil algae, fungi, actinomyces, protozoa and the non-protozoan soil fauna. A special chapter dealing with the chemical activities of soil microorganisms has been extensively revised, and though in the revision its allotment of space has been reduced somewhat, this has been affected without sacrifice of essential matter. Moreover, throughout the whole book, and particularly in the expanded section on microbiological processes in relation to soil fertility, the biochemical concept of the various transformations is kept adequately in sight.

The work is unique for the completeness of the essential references to the whole literature of soil microbiology and biochemistry. Well over 4,000 references are given, over 1,000 more than in the first edition, and for this feature alone the book will be an invaluable part of the equipment of every worker in the field. Throughout the whole volume there is evidence of the same painstaking preparation and logical presentation of the subject matter which characterized the first edition. This second edition will only serve to enhance the reputation gained by the first, and entrench Waksman's "*Principles*" more firmly than ever as the outstanding work on soil microbiology.

—A. G. Lochhead.

SOILS GROUP OF THE C.S.T.A.

ABSTRACTS OF PAPERS DELIVERED AT THE ANNUAL MEETING ¹

NOTES OF THE MOVEMENT OF WATER IN DRY LAND SOILS. S. Barnes. Dominion Experimental Station, Swift Current, Saskatchewan.

Over large areas of Western Canada moisture is the limiting factor in crop growth. Precipitation is rarely sufficient for normal crop needs so that a reserve of moisture in the soil is essential. Fluctuations in precipitation sometimes produce drought conditions and form the most serious handicap to successful crop production.

The importance of the upward movement of water through the soil has been over-emphasized. Water used by crops comes from the natural precipitation percolating into the soil from the surface.

Most of the economic crops completely exhaust soil moisture, during their growth, within range of the plant roots, which may extend to a depth of 4 to 5 feet in the case of spring seeded cereals. The remoistening of this soil takes place progressively, beginning at the surface and gradually extending downwards. Moisture penetration is limited by the initial moisture content of the soil, the amount and distribution of precipitation and evaporation.

BASE EXCHANGE STUDIES OF SOME RED RIVER SOIL ASSOCIATES. J. H. Ellis and O. Caldwell. Manitoba Agricultural College, Winnipeg, Manitoba.

Soils with solonetz-like (flat topped hexagonal prismatic) structure which develop problems such as increased plow draft, slow percolation of water, etc., are found in association with the clay chernozem in the Red River Valley. In studying these soils, profiles typical of the different associates of the clay association were selected. The soil profiles studied include (a) the Red River Phytomorphic Associate (with characteristic granular structure); (b) the Alkalinized-like or solonetz-like Associate (with flat topped prismatic structural aggregates); and (c) the Degraded Associate (with grey round topped pillared aggregates). The exchangeable bases were determined in, and some physical studies were made of, soil material from the various soil horizons of these soil profiles. The physical determinations made on the material from the different soil horizons included the relative rate of percolation of water, the plasticity number, the upper and lower plastic limit, the scouring point and the linear shrinkage.

None of the soils studied showed more than a very small quantity of absorbed sodium in the exchange complex (a trace to 1.7% of the total bases expressed as milliequivalents) the total sodium and potassium together only running around 5%. Hence, the clay soils of this area which showed hexagonal prismatic structure cannot be considered as being formed under the influence of soda or as being alkalinized in the usual sense of the term. The divalent cations are dominant in all of the soil associates. They constitute about 86% of the total absorbed bases in the Phytomorphic associate (which has characteristic granular structure) but in this case the ratio of calcium to magnesium is found to be approximately a little more than 2:1.

In the soil associate which showed flat topped hexagonal prismatic structure, the total divalent cations and the sodium potassium and hydrogen were practically in the same amounts as in the Phytomorphic associate, but the ratio of calcium to magnesium was 1:1.

In the Degraded soil associate which had grey round topped columnar structural aggregates the divalent cations had decreased to approximately 80% of the total absorbed bases, and hydrogen, but the calcium had increased to over 40% and the hydrogen to 16%.

¹Second meeting of the Soils Group held in conjunction with the twelfth annual convention of the C.S.T.A. at the Manitoba Agricultural College, Winnipeg, June 15-16, 1932.

The physical properties of these soils are markedly affected by the change in the ratio of the absorbed bases. Dispersion and the plasticity increased with the decrease in calcium and the increase in magnesium. The studies indicate that the Alkalinized-like associates of the Red River clay which have solonetz-like structure are not true solonetz or soda soils. Apparently the prismatic structural aggregates are a manifestation of physical phenomena which develop in the fine textured lacustrine clays when they deflocculate as the result of replacement of the calcium by magnesium. This is subsequent to the removal of reserve calcium carbonate under above-normal moisture conditions.

THE MICROORGANISMS OF MANITOBA SOILS. N. James, G. R. Bisby and M. C. Jamieson, Manitoba Agricultural College.

Microorganisms in the Manitoba soils examined are as abundant as in soils that have been studied in other parts of the world. The soil fungi average more than 100,000 viable spores or fragments of mycelium per gram of soil from cultivated fields. About a hundred species of fungi have been isolated. The commonest soil fungi are saprophytes such as *Penicillia* and *Mucorales*, but parasitic fungi, such as certain species of *Fusarium*, *Helminthosporium*, *Rhizoctonia*, etc., are isolated occasionally. The soils investigated were found to contain four or five million viable *Actinomyces* per gram, and about ten million bacteria, among which is the beneficial *Azotobacter*. An effort is being made to correlate the number and types of microorganisms with the type and fertility of the soils.

SOIL STUDIES IN RELATION TO AGRICULTURAL RESEARCH. Tennyson D. Jarvis, Ontario Research Foundation, Toronto, Ontario.

In this paper emphasis was laid on the importance of considering soil surveys as part of an agricultural research programme, rather than as an isolated problem. "A soil type has no agricultural possibilities apart from the particular environmental coincidence in which it may occur." Consequently all soil studies must be related to local environmental coincidences and land utilization policies based on consideration of local ecological and economic possibilities.

To supply the data necessary for carrying out their provincial agricultural research programme, the Ontario Research Foundation has instituted a system of soil survey which is proving most successful. In planning these studies it was recognized that data and conclusions must be assembled and correlated in such a way that they would be intelligible and valuable to the farmer and extension service as well as the research worker. At the same time results must be obtained by the speediest and least costly means. Consequently, all soil types are related to individual environmental coincidences and land utilization studies based on consideration of all local ecological and economic factors. Identification of soil types is facilitated by profiles and paintings in natural colours made in the field, the latter being necessary for identification of those soils whose natural colours change considerably on exposure to air.

THE PREPARATION OF A GENETIC SOIL MAP OF CANADA AS AN OBJECTIVE OF THE SOILS GROUP. A. H. Joel, University of Saskatchewan, Saskatoon, Sask.

This paper appears in full in this issue of *Scientific Agriculture*.

PRESERVATION OF SOIL MONOLITHS. F. F. Morwick, Ontario Agricultural College, Guelph, Ontario.

This paper appeared in full in the September, 1932, issue of *Scientific Agriculture*, Vol. XIII. No. 1.

SOIL MICROBIOLOGICAL ACTIVITY AS INFLUENCED BY CROP SEQUENCE. J. D. Newton, University of Alberta, Edmonton, Alberta.

The experiments were started with the main object of comparing the effects of timothy, brome, western rye grass, and alfalfa on the yield and quality of succeeding wheat crops. Four crops, alfalfa, timothy, western rye grass, and brome grass, were sown in quadruplicate plots, according to the Latin square system, in each of three sub-blocks.

When alfalfa plots were plowed up nitrification proceeded more rapidly, or nitrates accumulated to a greater extent, than in the case of the plowed up grass plots. When the grass plots were plowed up, on the other hand, nitrification proceeded less rapidly, or nitrates accumulated to a smaller extent following brome than following timothy and western rye grasses. No great differences in water soluble phosphorus in the soil under the different crops could be detected.

Generally speaking the differences in bacterial numbers between different plots were not very significant. In the sod plots the counts of fungi were highest under alfalfa for three successive years. Under the first crop of wheat following sods, it was repeatedly observed that large *Mucor* colonies predominated in the alfalfa plots. It was also observed that under the first crop of wheat following sods the brome plots gave by far the highest counts of fungi, and that these consisted mainly of small *Penicillium* colonies.

A definite relationship between the kind of sod plowed down, the kind of fungi bringing about its decomposition, and the rate of nitrate production has thus been observed in the cases of both alfalfa and brome grass.

THE DISTRIBUTION OF READILY SOLUBLE PHOSPHATE IN REPRESENTATIVE ONTARIO SOILS. H. W. Lohse and G. N. Ruhnke, Ontario Agricultural College, Guelph, Ont.

Readily soluble phosphates extracted by five minutes shaking with a KHSO_4 solution at a pH of 2.00, vary much in vertical distribution in the different profiles. Therefore, examination of surface soils alone is inadequate. In determining the readily soluble soil phosphates it is desirable to extract all horizons at a pH where reprecipitation of the dissolved phosphate is prevented and the pH value of the solvent should remain constant throughout the extraction.

In these studies, sandy podzol soils appear to be very low in readily soluble phosphate in all horizons, the parent material included. Clayey podzols and Brown Forest profiles contained large amounts of readily soluble phosphate in the B horizon and in the parent material. Cultivated soils of the Brown Forest group contained in all cases, considerable amounts of readily soluble phosphate in the lower horizons. The investigations on typical profiles from cultivated Brown Forest Soils, well known as to their fertility, indicate that the Potassium bi-sulphate extraction method referred to above gives a good index to the fertility of these soils, as far as their phosphate supply is concerned.



NATIONAL CONFERENCE ON AGRICULTURAL SERVICES

TORONTO, ONTARIO, AUGUST 29 - SEPTEMBER 1, 1932.

Ministers of Agriculture (front row left to right): Hon. D. G. McKenna, Manitoba; Hon. Michael Grollbut, Quebec; Hon. William Aikman, British Columbia; Hon. O. P. Goucher, Nova Scotia; Hon. Lewis Smith, New Brunswick; Hon. George Hoadley, Alberta; Hon. Robert Weir, Dominion of Canada; Hon. W. C. Buckle, Saskatchewan; Hon. G. Stephen Sharp, Prince Edward Island; Hon. Thomas I. Kennedy, Ontario.

PROVINCIAL CONFERENCES ON AGRICULTURAL SERVICES TO BE HELD

Following the agreement reached by the Ministers of Agriculture meeting with a group of leading technical agriculturists at the National Conference on Agricultural Services in Toronto during the week of August 29th, several Provincial Conferences will be held during the next few months. Out of these meetings at which will be discussed the relationship of various departments and institutions serving provincial agriculture it is expected that there will be organized in each province a Provincial Advisory Committee on Agricultural Services to work with the National Advisory Committee sanctioned at Toronto. Very briefly, the situation discussed at Toronto and the conclusions arrived at may be stated as follows.

In the consideration of machinery to promote co-ordination the whole emphasis was thrown on particular agricultural problems and the workers grouped around those problems rather than on the departmental or institutional set-up as it now exists. This applies to both research and extension, using these terms in a broad way. Thus it was noted that there already exist in the provinces several committees which in each case group workers from various services around the many phases of a common problem. As might be expected, these committees have functioned with varying degrees of success. In the majority of cases, however, it was felt that such committees provided the only machinery by which any measurable degree of co-ordination could be achieved. Such committees not only bring together research workers from different services both governmental and non-governmental, but often combine research, administration, extension, and control services to an extent which hastens considerably the solution of a research problem and the modification of farm practices accordingly.

Acknowledging the value of many of these committees already in existence, the Toronto conference felt that there should be established in each province a Provincial Advisory Committee on Agricultural Services which, in the words of one of the delegates, would "see that there is an uniform standard of efficiency and activity on the part of these various problem committees within the province," and which would "fill in the gaps" where such committees are not in existence but are obviously needed. In some provinces such conferences have been held in previous years and in two or three provinces the machinery is already in existence and needs only to be fitted into the national scheme. The Provincial Minister of Agriculture will in each case be chairman of the Provincial Advisory Committee.

The same reasons which make it logical to form Provincial Advisory Committees point to the necessity of a National Advisory Committee. Many problems overlap provincial boundaries, and several regional and national problem committees are already in existence. We have also several technical societies representing different fields of agriculture organized on a regional or national basis. Again it would seem advisable to endeavour to promote "an uniform standard of efficiency and activity" and to "fill in the gaps." Discussions conducted at the conference on major problems of Canadian agriculture revealed a sufficient variation in standards of service and enough gaps between services to impress every one with the need for some unifying body. The conference consequently recommended the formation of a National Advisory Committee on Agricultural Services composed of the administrative heads who will be leaders in the Provincial Committees and including also representatives of several important provincial and national organizations outside of the government services.

The Provincial Ministers of Agriculture as heads of the Provincial Advisory Committees are to form a National Committee on Agricultural Services with the Federal Minister of Agriculture as their chairman. This gives an official form to what has previously existed as a matter of courtesy. On previous occasions, when the need arose, the Federal Minister called the Provincial Ministers into consultation with him and each brought those advisors which he thought were necessary. Such

conferences have been held at infrequent intervals and have left no permanent set-up to insure continuity in their approach to their problems on future occasions or in the enforcement of their agreements. The Toronto conference by mutual consent decided on a definite plan to organize the agricultural services of the Dominion on a permanent basis with regular annual meetings. These are to be held under the leadership of the Federal Minister of Agriculture acting as chairman of the committee of Ministers. This committee will sit with an advisory committee of permanent officials whose duty it will be to provide sound technical advice and to guarantee a continuity of action which has hitherto been lacking in national conferences.

This, in brief, is the plan upon which we are to build during the next few months. Publicity has been given more to particular agricultural problems discussed at the conference than to this matter of co-ordination which, after all, is a matter to be worked out by the services themselves and which does not need general publicity. The fact that it is of interest to the tax-payer, however, must be kept in mind, and the following editorial comment from leading Canadian newspapers indicates that interest may be more wide spread than the agricultural services generally realize.

The Globe, Toronto. (Lib.) Extract from an editorial September 3, 1932.

"Reviewing the work accomplished by the Agricultural Conference held in Toronto and attended by representatives of all the Provinces, men familiar with the present condition and the needs of the basic industry, the conclusion must be that much of benefit to the farmer will follow.

There were differences of opinion as to the character of committees to be established for the carrying out of plans looking toward advancement of the interests of agriculture, but as wise men keenly concerned about the work undertaken, compromise was reached. Finally it was decided that there should be formed a body consisting of the Federal Minister of Agriculture and all the Provincial Ministers of Agriculture, this organization to have the advice and co-operation of a committee of Deputy Ministers and men prominent in agricultural research work. Provincial advisory committees also are recommended.

This decision means that the general committee will have both the national and provincial outlook. There will be an understanding of the varying conditions of agriculture in the different provinces, and this will inspire confidence in every locality that the needs of all sections will receive intelligent consideration; while the character of the men on the committee ensures that they will have also the broad national view on the requirements of Canadian agriculture."

The Ottawa Journal, (Con.) Extract from an editorial September 1, 1932.

"The decision, arrived at in Toronto Monday, to form a national advisory council to co-ordinate all agricultural services in the Dominion, is one of the most important affecting Canadian industry that has been made in years. The drawback to all agricultural progress in Canada for years has been duplication of effort, a certain jealousy between Dominion and provincial officials, and multiplicity of organizations without a central clearing point. The formation of the advisory council marks the first practical step to enable Canadian agriculture to take advantage of the very obvious preferences granted it in the recent Conference agreements.

The meeting being held in Toronto all this week was called by Hon. Robert Weir, Dominion Minister of Agriculture, and is being attended by nine provincial ministers of agriculture, most deputy ministers, heads of agricultural colleges and important figures in the industry. If some working arrangement can be made whereby the duty of each group or unit is clearly defined and an agreement reached that disputed points will be submitted to the national body then a fine week's work will have been accomplished."

The Financial Post, Toronto, (Ind.) Extract from an editorial September 10, 1932.

"Just what these committees will accomplish remains to be seen. It will be difficult to get all these men together except perhaps once a year, but if the

expressions of unanimity voiced at the conference in regard to federal and provincial co-operation on vital national problems are more than lip service, a very real advance has been made in the interests of agricultural development. Apparently the resolve for greater co-operation is already bearing fruit in the announcement this week that Quebec will shortly hold a further conference with federal officials to establish closer co-ordination between the two jurisdictions. Ontario and Ottawa have already made considerable strides in this direction but other provinces have too often been content to go their own way, with an unfortunate and unnecessary overlapping of services.

Another important result of the parley is that it achieved definite results in bringing more closely together the agricultural experts of the Dominion and the political leaders through whom the former body becomes, in the main, articulate. It is not the first time, for instance, that the several ministers of agriculture have gathered to discuss matters of policy but never before has there been in Canada such a representative gathering of political leaders and experts at the same time.

A glance at the agricultural export record of Canada during the past decade provides adequate testimony of the need for every available ounce of brain and brawn co-operating to ensure that Canada will be able to take advantage of whatever new channels of trade are opening up as a result of the Empire conference. The major sins of lack of continuous supply and insufficient attention to quality production and proper marketing procedure are too well known to bear repetition.

But preferences, as most of us know, are only one step in a long highway which must be traversed before we reach our envisaged goal of a goodly share in the largest importing foodstuffs markets in the world. To Mr. Weir goes credit for losing no time in calling the National Agricultural Conference. As in the case of the British preferences, however, this is but the first step and the manner in which the federal minister follows up his first advantage will be closely and eagerly watched by all interested in finding some solution to our sorely-pressed agricultural problems via the export market route."

Similar editorials appeared in many of the leading Canadian papers. Farm journals commented mainly on particular problems in agriculture which were discussed at the conference rather than on the formation of the proposed committee. There was an occasional disagreement with the purposes of the conference, as set forth in a press dispatch quoting Miss Agnes McPhail, M.P., speaking at Kincardine on Sept. 12th.

"Advice from so-called farm experts was scorned by Miss MacPhail. Referring to the recent agricultural conference in Toronto, she said: 'They weren't actually dirt farmers. When such men say that the farmer needs a wider and more scientific knowledge of his work, it is time to clean up on them. Production is not the problem of agriculture. We have solved that. What a farmer must do is to find markets. I don't want any one to think I am humbugged by that kind of twaddle.'"

C.S.T.A. ANNUAL FEES

In a recent letter which was sent out reminding members that their fees for the current year, June 1932 to May 1933, were due, the amount of these fees was not stated. This was not entirely an oversight as the letter was intended to be more of a news item than a dunner. For the benefit of those, however, who have not been able to pay owing to lack of knowledge regarding the exact amount due, the sum is \$5.00, payable either to the General Secretary, 306 Victoria Building, Ottawa, or to the Secretary of your local whose name appears on page II of the front advertising section. Members are urged to remit their fees as soon as possible as there has been little revenue coming in to the Society during the summer months.

CONCERNING THE C.S.T.A.

NOTES AND NEWS

G. R. Paterson, (Toronto '24) formerly Feed and Fertilizer Specialist, Crops Co-operation and Markets Branch, Ontario Department of Agriculture, has left for London, England, where he is to act as Sales Representative for the Ontario Honey Producer's Association. His business address will be Ontario House, 163 Strand, London S.W. 2, England. Mr. Paterson was Secretary of the Central Ontario local of the C.S.T.A. in Toronto.

A. H. Martin, (Toronto '24) Assistant Director of the Crops Co-operation and Markets Branch of the Ontario Department of Agriculture, has taken over Mr. Patterson's duties as Secretary of the Central Ontario Local.

A. L. Harrison, (Toronto '29) Department of Plant Pathology, Cornell University, Ithaca, N.Y., was married to Miss Alice Johnson of Worcester, Mass., in August.

C. F. Taylor, (McGill '29) Department of Plant Pathology, Cornell University, Ithaca, N.Y., was married to Miss Sarah Palmer of South Byron, N.Y., last April.

G. A. Ledingham, (Saskatchewan '27) is now at the Laboratories of Cryptogamic Botany, Harvard University, where he is doing post-graduate work on root parasites of wheat and other plants. His address is Biological Laboratories, Divinity Avenue, Cambridge 38, Mass., U.S.A.

R. W. Ward, (Acadia '32) is enrolled in the Graduate School of Harvard University in the Department of Botany. His address is 37 Perkins Hall, Cambridge, Mass., U.S.A.

J. G. Malloch, (Alberta '24) Biologist, Division of Biology and Agriculture, National Research Council, has moved from the University of Alberta, Edmonton, to Ottawa, where his address is in care of the above division.

W. J. Hopkins, (Alberta '29) formerly Research Assistant in Plant Biochemistry, University of Alberta, Edmonton, has transferred to Ottawa where he holds the position of Junior Research Biologist, Division of Biology and Agriculture, National Research Council. His address is in care of the above division.

J. A. Anderson, (Alberta '26), Junior Research Biologist, National Research Council, University of Alberta, Edmonton, has been transferred to the Division of Biology and Agriculture, National Research Council, Ottawa.

D. G. Hewer, (Toronto '30) Bacteriologist, Central Experimental Farm, has registered at the Faculty of Education, Toronto, in preparation for high school teaching work. His address is 42 Maitland Street, Apartment D-3, Toronto, Ont.

J. C. Woodward, (McGill '30) has completed his work on "The Effects of Synthetic Diets on Herbivora," for which he received his Master's Degree from Cornell University in June 1932. He is now engaged in a problem in deer nutrition for the New York State Conservation Department, and is registered for his Doctor's Degree with a major in Animal Nutrition and minors in Biochemistry and Physiology. His address is Laboratory of Animal Nutrition, Cornell University, Ithaca, N.Y.

H. L. Patterson, (Manitoba '30) is doing field work for the Department of Farm Management, Cornell University, Ithaca, N.Y.

C. J. Watson (McGill '21) Chemist, Central Experimental farm, Ottawa, has changed his address to Apartment 1, 20 Patterson Avenue, Ottawa, Ont.

C. R. Asher, (British Columbia '28) formerly Salesman, Canadian Industries Limited, New Westminster, B.C., has been transferred to the headquarters of Canadian Industries Limited, Montreal.